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MOULDING GROOVED PULLEYS.

MACHINE moulding has justified its existence if for nothing else than having been the means of bringing more brain power to bear on many of the methods formerly adopted in the foundry; an element which has hitherto been in many cases too conspicuous by its absence.

New ideas are beginning to prevail in all matters relating to the foundry.

These may be attributed to several causes, but we are of opinion that they are to a large extent being forced upon us by competition.

We have too long been content to carry through our work on stereotyped lines,

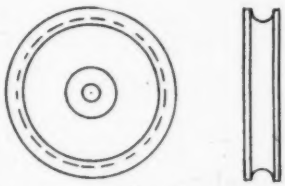

FIG. 1.

but we are happy to record that this state of matters is fast giving place to methods based on thorough up-to-date principles. The introduction of machine moulding has been the means of revolutionising to a great extent many of our former methods, and at present quite a state of unrest prevails in many of our foundries owing to the universal adoption of this class of moulding in its different forms.

It has been clearly demonstrated that if we are to keep our position in the world's trade, we must make ourselves efficient, and adopt measures for producing our work which will place us on a better, or at least as good, position for doing so as our competitors.

It is not our intention to enter into the merits or demerits of any particular class of machine, but to make some observa-

tions on that form of machine with which the use of stripping plates is associated.

The benefits to be derived from the free use of this class of moulding for repetition work cannot be over-estimated, and by means of which methods hitherto thought impossible have now become a matter of every-day practice.

for a considerable quantity, the above method was considered too laborious, and an endeavour was made to substitute for it some arrangement less complicated, and by means of which the work could be turned out more expeditiously and with greater economy.

The method adopted, and to which we

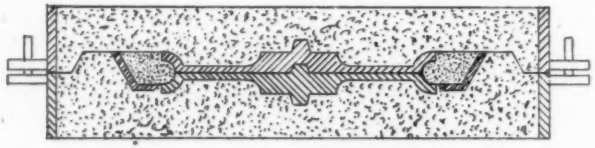

FIG. 2.

This now brings us to the subject to which we wish specially to draw attention, and which is in connection with the aforesaid class of moulding, and came under our observation some time ago in connection with an order for some small grooved pulleys (see Fig. 1), a description of which may be of interest.

The usual method of producing these wheels, as is well known, is to mould them with the groove parallel to the parting; the pattern being in two pieces.

wish to draw attention, is worked on entirely different lines from the usual arrangement, as will be observed from the following description:—The parts comprising the machine are the stripping plate, spindle, and patterns, as shown on Figs. 3, 4 and 5 respectively.

The stripping plate is prepared with openings the same size and shape as the section of the wheel; the number of these openings corresponds to the number of patterns to be used, which, of course, is

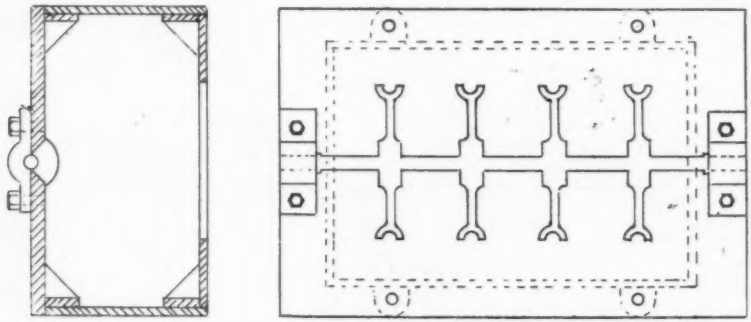

FIG. 3.

This method necessitates the use of a "drawback" in the shape of an iron ring which carries the core forming the groove, this ring being removed from the mould after the top portion of the pattern is taken away, and is again placed in position when the bottom part is withdrawn.

Fig. 2 shows a section through the mould with all parts in position.

For the order in question, which was

regulated by the dimensions of the moulding box.

An opening equal to the diameter of the spindle runs the entire length of the stripping plate, and finishes at either end with a bearing, into which the spindle is secured.

The bearings are so arranged that the centre of the spindle, when in position, will be in the same plane as the face of

the stripping plate. The spindle rod is prepared with square bosses left on at the points where the patterns are to be fixed. A handle is placed at each end, together with two journals, which work into the bearings at the ends of the stripping plate.

The moulding box is placed in position and rammed up in the usual manner. Fig. 6 shows a section through one of the halves of the mould with all parts in position.

After the box is rammed, it is temporarily fixed to the stripping plate, and

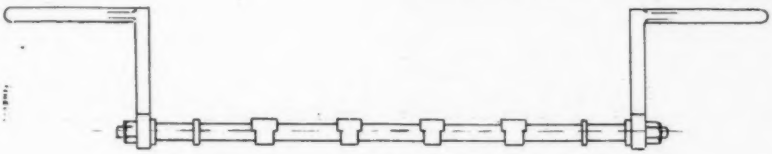

FIG. 4.

The patterns, as will be observed, are only halves, except the centre boss, which

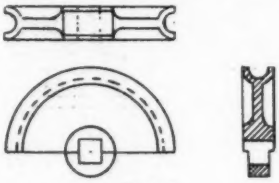

FIG. 5.

is carried round its full diameter, and into which are put square holes, corresponding in size to the square parts left on the spindle.

the handles given a half-turn, with the result that the patterns are revolved right out of the mould, as shown in Fig. 7.

The only part apparently in the mould is the part of the boss which was left on the pattern to get a fixing to the spindle, but as this part is made narrower than the other half of the boss (see Fig. 5), there is no part of the pattern in actual contact with the mould.

The mould can therefore be lifted off with perfect safety.

The patterns are brought up by again turning the spindle handles, and the same process is gone through with the other half of the mould, and when both halves are brought together the complete mould is thus formed.

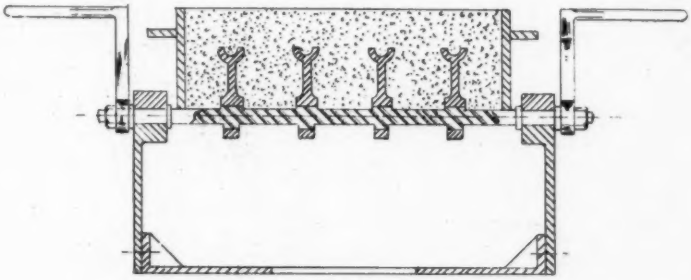

FIG. 6.

The patterns are fitted on to the spindle, which in its turn is fixed in to the bearings on the stripping plate, and the machine is now ready for the moulder.

The stripping plate is prepared in the usual way to receive the moulding box, and as the patterns in this case are symmetrical, the top and bottom halves of the mould can be made from the same plate.

The only part now to be dealt with is the recess left in the mould by the spindle

This may be used as a core print to form a hole through the wheel, or if the wheels are wanted solid and bored afterwards, the core can be brought to the edge of the mould on either side, and in this way make the wheel solid.

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BRITISH FOUNDRYMEN'S ASSOCIATION.

Birmingham Branch.

A MEETING of the Birmingham Branch of the British Foundrymen's Association was held at the Technical School, Suffolk Street, Birmingham, on Saturday, December 15, under the presidency of Mr. R. Buchanan, President of the Branch.

A lecture had been announced on "Moulding Sands" by Mr. Percy Longmuir, but the CHAIRMAN explained that Mr. Longmuir having been unable to carry the subject further than in the paper given at Glasgow, decided to change the subject. Instead, he proposed to speak on "Two Foundry Problems."

MR. LONGMUIR then delivered his lecture, which he prefixed by the enumeration of the following conditions as governing success :—

1. Composition of metal or alloy.
2. Method of melting, change of composition, absorption of oxide, influence of gases.
3. Initial casting temperature.
4. Preparation of mould.
5. Presence of blowholes, foreign matter, sand, slag, etc.
6. Shrinkage faults, inefficient feeding.
7. Contraction faults.
8. After-treatment in the case of white iron and steel.

Waters generally represent a violation of one or other of these conditions, faulty moulding, for example, being readily shown in the resulting casting, and unsuitable composition by analysis. In the majority of cases causes must be ascertained (1) by examination of the casting; (2) by chemical analysis; or, (3) by microscopical examination. But some could not be so ascertained, and in reviewing many of the so-called mysterious wasters the speaker attached considerable importance to (1) oxidation, and the retention by the metal of the resulting oxide, and (2) varying casting temperatures.

The retention of oxide by metals or alloys is a problem of very direct interest to founders, examples of this being taken from pure iron, copper, and nickel, where the oxides are retained, as also from zinc, where the oxide is emitted. Examples of deoxidisers were given, and emphasis was laid on the fact that any loss of zinc present in an alloy should be made good before casting.

A series of tensile tests were given, showing that for all alloys there is a precise casting temperature, at which alone the full properties are obtained. Castings poured above or below this heat invariably have lower mechanical properties, and offer less resistance to steam or water under pressure.

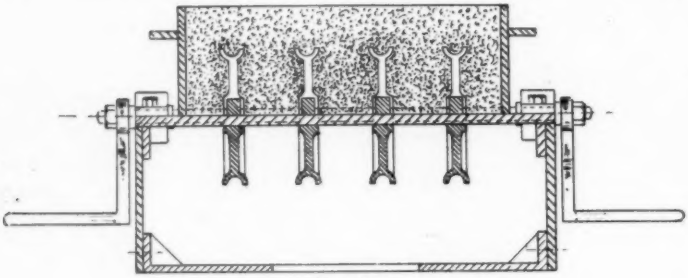


FIG. 7.

The following results are typical of the tests given, showing the variation in properties due to varying casting temperature :—

Copper.	Zinc.	Casting temperature.	Maximum stress. Tons per sq. inch.	Elongation percentage on 2 in.
89.6	10.2	1308	6.8	13.2
—	—	1073	12.6	26 0
—	—	1038	5.7	5.5

The only variation in this and other examples quoted was that of initial casting heat, and in the case of white iron and steel the speaker showed the persistence of the variation through heat treatment.

A discussion followed.

The CHAIRMAN remarked that they claimed to know something of copper in Birmingham.

MR. A. H. HIORNS considered the lecture was more instructive and interesting than the one on moulding sands could have been, but he would like to know what explanation Mr. Longmuir would give as to what actually took place which gave such diverse results.

MR. F. J. COOK paid a tribute to the thoroughly practical character of the paper. He would like to know whether oxidation and variations in temperature had any relation with each other.

The CHAIRMAN said a short time ago he heard a suggestion as to the use of titanium

as an addition, but he would like to know whether the oxide would combine with the iron or pass away with the slag. There seemed some mystery about poor results coming from both high and low temperatures, and, like shrinkage, it was a thing no fellow could understand. His own experience seemed to show that getting the iron as hot, or almost as hot, as they could from a cupola gave the best results. He had made some experiments with levers, cast at the weight of 13 cwts. Some of these broke at 34 cwts., and others at 26 cwts. But he thought, in that case, it was a case of the rate of cooling increasing the size of the crystals. They had really got to consider temperature, plus the rate of cooling, and those were the questions which made foundry work so interesting, but also, occasionally, so tantalising.

MR. LONGMUIR, replying on the discussion, said he had no theory to explain the similarity of results in high and low temperatures. Metallurgy as a science had suffered from immature theories, and it was their duty not to add to the number, unless something definite could be given; but every pure metal seemed to have a particular temperature at which the best crystalline cohesion was developed. If they took pure iron or pure copper, and examined the crystal junctions, they would find that as they approached what was called a fair heat the junctions were narrow, and the crystals dovetailed one into each other. At high temperatures they appeared loose, not holding firmly against each other, and under magnification the whole looked lacking in grip. The low casting temperature crystals had distinct spaces between certain junctions, and if the crystals were dovetailed one into the other, there were no interstices between the crystal. With loose crystals, water was very likely to be driven through under pressure. As to the absorption of oxide, he did not believe in it much, because if they took the Bessemer converter as an analogy, the first materials to be oxidised were manganese, sulphur, and carbon, the iron being the last. Dr. Moldenke was very strong on the presence of oxide of iron in the cupola, and oxide was taken up in passing through the cupola. One could not help thinking that there was some affinity between the highly-driven modern furnaces, and the oxide in the iron. That was why many people preferred iron from a small furnace. The temperature of a normally-worked cupola could never be called high, and if properly worked could not be excessive. In the commercial foundry he did not think that was generally done.

There was a large attendance of the Birmingham Branch of the British Foundrymen's Association at the Technical School, Birmingham, on Saturday, the 19th January, under the presidency of Mr. R. Buchanan, to hear a paper by Mr. George Hailstone on "The Characteristics of Foundry Irons." A series of micrographs, showing the constituents of large, small, and medium castings of different qualities were exhibited. The CHAIRMAN, introducing Mr. Hailstone, referred to him as an old pupil and assistant at the Technical School, now engaged in large Birmingham works making a series of tests with cast-iron and other metals, the result of which were now to be given.

The lecturer showed the effects of the different elements upon iron. There was a wide difference between the different irons used in foundries, each district producing its own peculiar quality. With regard to testing, he thought one of the easiest methods was to take half a pig out of a five-ton lot and drill it from top to bottom, through the centre, which would give them a fair sample, and such iron might be confidently depended upon. Scrap should be used sparingly in thin castings, and in larger proportions in the heavier ones, with the object of improving the quality rather than cheapening the production. But they should use their own scrap wherever possible. They knew its constituents, but "bought in" scrap was a doubtful quantity, very difficult to sample. Dealing with defects, the lecturer ascribed blow holes to too high a percentage of sulphur, damp sand, the presence of dirt, the breakage of part of the mould, the shortage of metal, the use of unsuitable coal or coke, and the bad pouring of the metal. The quality of iron must be adapted to the size of the casting. The iron which would suit a strong casting would make a light one hard and flinty. More sulphur and less silicon were required for the bigger ones. Cementite, pearlite, and graphite formed strong iron, whilst the presence of crystals of ferrite showed the casting to be weak.

MR. HIORNS opened the discussion, pointing out the great value of the Association in circulating by such papers practical information. It was impossible to stand still, and in view of the great advantages the young men now had, older men might be proud of their achievements. He was proud of Mr. Hailstone as an old student. Generally, the lecturer's conclusions agreed with the experiments he had himself made. The lecture clearly showed that one kind of iron, however good, would not do for everything. They saw at a glance the enormous variation in silicon. A fracture was unreliable for sampling purposes. Some experiments he had himself made showed that if pure cast-iron with carbon were allowed to cool very slowly the graphite separated out. He would like Mr. Hailstone's ideas as to why more scrap

iron should be used for heavier castings than for light ones.

Mr. Hailstone explained that light castings cooled quickly, allowing little time for the graphite to separate out, and as the scrap contained much less carbon than pig-iron they got a casting drawing and sinking. With heavy castings, which took longer to cool, the graphite had more time to escape, and therefore they got a lower total of carbon.

Mr. Hiorns, referring to bought scrap iron, pointed out that the quality might vary much.

Mr. Buchanan explained that his practice in dealing with lots of, say, 300 tons, was to take 22 pieces of stuff from different parts of the heap, and to drill these samples.

Mr. Hiorns said fractures were insufficient without analysis. With reference to alloys, the names of which he would like to know, he should have thought they were rather costly.

Mr. Barker (Rugby) mentioned one alloy selling at £16 a ton, and another, marked S.A.M., at about the same price.

Mr. Hiorns thought the percentage of phosphorus and sulphur in motor-car castings was very high. That was dangerous, and might account for many of the numerous accidents. Next time he heard of a motor-car failing he should be inclined to blame the ironfounder. (Laughter.)

Mr. F. J. Cook agreed that phosphorus was too high in motor-car cylinders. Allowing for variation in class of engines, it was still excessive. It was quite a common occurrence on a run of 50 miles for a cylinder to become red-hot. Clearly 1½ per cent. of phosphorus was too much.

Mr. Barker pointed out that high phosphorus was necessary to form thin cylinders, and no two makes were alike.

Replying to Mr. Mason, Mr. Hailstone said that an increase of 1 per cent. of manganese largely increased the shrinkage.

Mr. Foster (Darlaston) said he knew sulphur had the greatest influence on fractures, and the great difference between hot and cold blast iron depended greatly upon the carbon. With cold blast iron they had less separation of carbon.

Mr. Barker said the difficulty with drilling from top to bottom arose from the dirtiness of the pig. Fracture was the cleanest method, and he had found the fractures of one pig per five tons with a drill into the middle of the fracture the best method. "Home" scrap was the only reliable stuff to use because they knew its character. But outside scrap might be used to cheapen production of cheaper iron. His own experience was that he saw trouble when they began to use outside scrap. The difference between hot and cold blast was not so much one of carbon as one of heat.

Mr. F. J. Cook preferred Mr. Hailstone's method of drilling. His own plan was to have the pigs well scrubbed, and to start with a drill a shade larger than the one he afterwards used.

Mr. Hailstone, replying, explained that only a small proportion of alloys were ever used. In motor-car cylinders, unless a sufficient percentage of phosphorus was used, the cylinder parts would go into holes. He had found that a very small quantity of sulphur neutralised a much larger quantity of silicon. As to testing, it was no doubt necessary to clean the back, top, and bottom of the pig before starting, and he always did so. Of course, they only used outside scrap under compulsion, but they might, as an alternative, use a lower number of pig-iron.

The Chairman announced that arrangements were being made to have the paper printed.

The proceedings concluded with a vote of thanks to the lecturer.

——o——

MOULDING A LARGE GEAR WHEEL.

By S. Groves.

In no branch of the art of founding is there demanded of the moulder more skill, patience, resource, and intelligent perception of the laws of cause and effect than in the moulding of a 12-ft. double helical split gear, weighing some 12 tons, in which the pitch diameter and depth of face must not appreciably vary, the teeth be equidistant, and so clean that neither file, hammer, nor chisel must be used on the flanks of any of them; and yet, with properly designed machines and experienced artisans, it is possible to approximate to this degree of perfection.

Notwithstanding the manifest advantages of machine moulding, it is astonishing to find how tenaciously some people cling to the antiquated. Some time ago we visited the foundry of a large engineering concern, and to our amazement saw them moulding a gear wheel about 6 ft. in diameter from a full pattern. The foundry floor was used for the drag, and just as we were passing, four men—each with one hand on the sling chain, shaking, and the other with a bar vigorously rapping the top of a spike driven into the water-soaked pattern—were trying to hoist the pattern out of the sand with the aid of a crane. When it was finally lifted out, a sorry plight

the mould presented, for in several parts the sand forming teeth spaces had been carried away with the pattern, and these defects in the mould had to be made up again by patching. One has only to witness this antediluvian method of moulding to realise how it is that large gears made from costly full patterns are almost invariably irregular in form, defective in pitch, and when in gear touch only on one side of the face. In view of the increasing perfection and refinement in modern machinery, it is not surprising that the cut gear has almost entirely displaced the old uncouth cast gear with uncut teeth. But just as an axe is better than a razor to cut down a tree, so, in the fitness of things, there are innumerable cases where the moulded-tooth gear is preferable to the gear with cut teeth. In machinery where the shaft centres seldom vary, the cut gear, with its deadly accuracy of pitch is manifestly the best; for as long as the gear centres remain intact the wear on the teeth will be practically nil, since, in accordance with the laws of mechanics, the teeth will roll on the pitch circles and not grind. On the other hand, in machinery subject to intense strength and violent shock—rolling mill, stamp press machines, etc.—the bearings wear away rapidly, the gears lose their centres, the teeth begin to grind instead of rolling, and the tale of woe is soon told: broken teeth and costly stoppage of plant. Now in gears where the grinding of gear teeth is inevitable, even in the best machines—due to unavoidable natural causes—gears with uncut teeth are immeasurably superior to cut teeth, because the skin of fine uncombined carbon left on the teeth of the moulded gear offers a much better wearing surface than does the coarse grain forming the surface of the cut teeth, from which the hard skin of combined carbon has been removed. The only advantage of cut gears is guaranteed accuracy of pitch. Experience has demonstrated, however, that while machine-moulded gears may not be perfectly adapted for clockwork, yet for all practical purposes, as applied to mill and mining machinery, they are even superior to cut gears, since they not only are practically accurate as regards pitch, but are superior in the matter of resistance to wear and tear: due to their retention of the hard skin of combined carbon. But even where it is proposed to make large gears to have cut teeth, machine-moulding is the better way, for instead of casting a double rim, and then cutting the tooth spaces out of the solid mass, it is a manifest advantage to leave around the teeth to be cut a film of metal, say $\frac{1}{8}$ in. thick, and thus conserve as much as possible of the close-grained metal next the skin. This wise plan is becoming more and more popular every day.

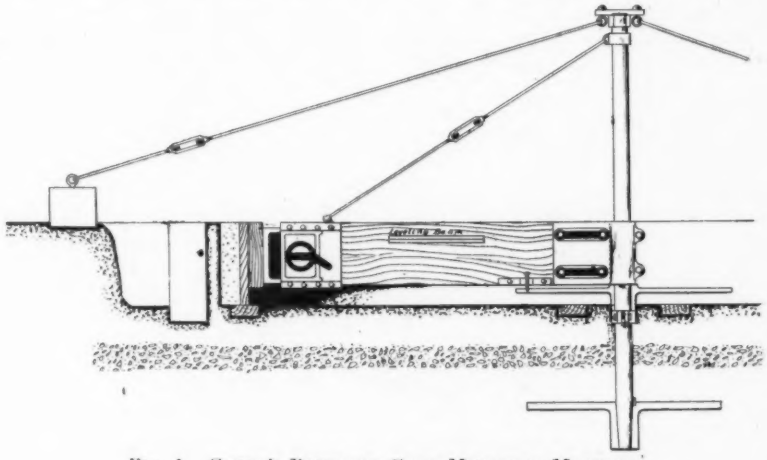


FIG. 1.—GROVE'S PORTABLE GEAR MOULDING MACHINE.

A common labourer can be soon trained to operate a fixed gear moulding machine with revolving table—for which, when he has once made successfully a spur, bevel or helical worm wheel, the process in each subsequent case is very similar, and the man becomes practically part of the machine. When, however, we come to the machine moulding of heavy wheels over 6 ft. diameter—which must be made in the floor, and not on a table machine for fear of injuring it as an instrument of precision—then we are confronted with an altogether different condition of things. The common labourer is no longer available; the moulder must be, in every sense of the word, a mechanic. Take, for example, a double helical gear 14 ft. diameter 4½ in. pitch, made in halves by means of splitting plates.

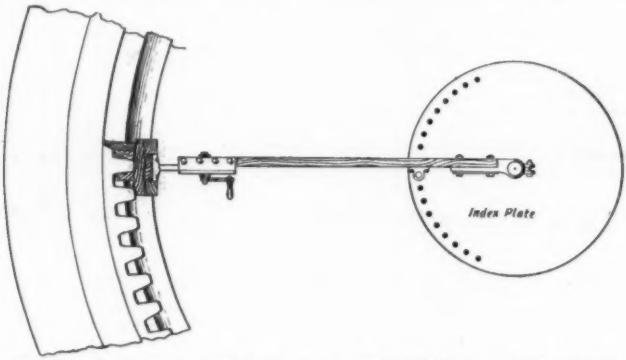


FIG. 2.—PLAN OF GROVE'S PORTABLE GEAR MOULDING MACHINE.

In the first place an excavation is made in the foundry floor, say about 7 ft. deep, and suitable anchor foundations laid thereon, with hooked bolts, secured in same. These anchor foundations are then covered with old sand, firmly tucked in, so that there is a 7 or 8-in. layer of hard-rammed sand over all, the only evidence of what is below being the large circle of anchor bolts standing up out of the floor. On this hard bed is laid a 7-in. layer of coke, in which is inserted at suitable points near the edges of the bed, a series of 4-in. pipes (see Fig. 4) for carrying off the gases generated by the burning of combustible material in the facings at the bottom of the mould when the hot metal is poured therein. On this bed of coke is rammed another 7 or 8-in. layer of moulding sand, forming practically the base of the mould. A 14-in. brick wall is then built around the pit—care being taken that these bricks are porous. The inner face of this porous wall is then painted with water, thickened with common aluminous clay, and immediately this moist clay wash-coating is covered with about 3 in. of coarse moulding sand, mixed plentifully with molasses water; and this layer is straightway covered with a thin coating of burnt black sand on account of its freedom from combustible organic matter, and at the same time possessing a rich residue of refractory silica. These preliminary preparations having been made, a heavy 36-in. base plate, with tapered socket, is firmly tucked and embedded in the centre of main foundation (Fig. 4), and a 4-in. sweep spindle inserted therein, braced with adjustable tie-rods, radiating from cap on top to heavy weights sunk in foundry floor. This spindle is fitted with swinging arm, provided near the inner end with pin for spacing teeth in index plate below (Fig. 2), and at the outer end with eccentric draw-back device, on which is fixed the tooth block, having the form of one tooth space. The perfect horizontality of the arm is regulated by a rod connected to spindle cap and end of extension arm, provided with adjusting

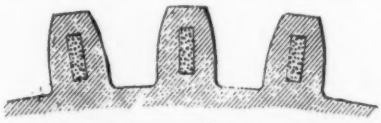


FIG. 3.—MODE OF VENTING GEAR TEETH.

turnbuckle, as shown (Fig. 1). A labourer operates the drawback machine and indexing device, inside the ring, under the direction of the skilled moulder who stands in the space outside the wall, with a bucket of facing-sand by his side, leans over the wall, and with a rod of iron in one hand, and sand in the other, feeds and rams the space in the tooth block. When this space has been filled, the labourer takes hold of the drawback handle, makes a complete revolution, and the tooth-space pattern is withdrawn clear of the moulds. This done, he lifts out the index pin, pushes the extension arm forward, drops the pin into the next hole in the index plate, takes hold of the drawback eccentric handle again, thrusts the tooth block up against the black sand backing once more, and the moulder commences to rain another tooth-space, and so on, until the whole circumference of teeth mould spaces are completed. Simple though this work seems, it demands all the skill and resource of an experienced moulder, for in selecting his facings several important conditions have to be observed. The fine-grained sands which he used for 1-in. pitch will not do for teeth 4½-in. pitch, the particles of silica in the sands must be coarser in order to render the facings porous, and thus allow for the free exit of the gases; it must be sufficiently cohesive to mould well and resist pressure, and sufficiently refractory to prevent the burning action of the hot metal. Further, the moulder, in ramming the teeth, must be able to judge exactly the necessary degree of force to impart to his rammer; the force applied in forming the tooth spaces for 1-in. pitch will not do for the larger sizes; and besides, the ramming must be uniform, since a hard spot here and a soft spot there will tell its miserable tale when the gear is lifted out of the sand, either in unsightly scabs or ugly swellings, necessitating the use of hammer and chisel. And I may remark here that in moulding the teeth of large gears of 3-in. pitch and upwards, it has been found necessary to vent the mould of each tooth space by leaving an oblong hole in the middle (Fig. 3), which is connected to the coke bed below by a vent wire and filled with fine particles of coke. Teeth moulds formed in this manner are afterwards coated with a refractory solution, and thoroughly skin-dried, not by the erratic heat of a coal or coke fire, but by a steady, regulated gas flame delivered through a 1¼-in. pipe, about 12 in. less in diameter than the mould and perforated with holes a few inches apart, so arranged that the flame does not play on the face of the mould. With the mould made and dried thus, teeth can be produced with sharply defined edges and flanks bright, smooth and clean.

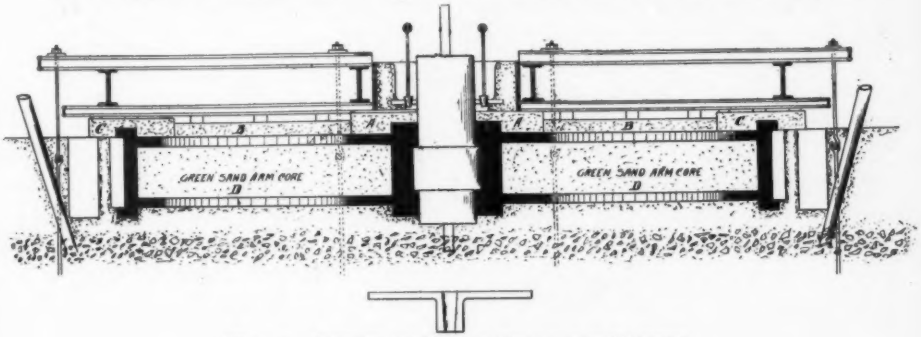


FIG. 4.—SECTION OF MOULD READY FOR CASTING.

Another important improvement in manufacture is the substitution of green sand for dry sand arm cores. This is one more instance of necessity being the mother of invention. If a large gear is to be true in diameter, there must be no resistance to general shrinkage. The shrinkage which takes place in the arms towards the hub must be followed by the rim between the arms also; anything which hinders this onward movement is detrimental to the diametral perfection of the gear. Hard-earned experience has proved that this is just what dry sand cores are found to do: hinder normal

shrinkage. I well remember a deplorable instance of this. It was a large gear, 7-in. pitch, 30-in. face, and when cast, a number of teeth were cracked transversely across the face, midway between the shrouds. The use of dry sand cores was manifestly the main cause of this mishap, for the arms were of I section, and as the metal in the top and bottom flanges shrank in towards the hub, it naturally drew the rim and whole face of the gear with it; but the hard dry sand cores resisted this, hence the metal in the teeth opened out in the middle. From that time forth I discarded dry sand cores, using only hollow, coke-filled green sand cores, made of coarse gravel The best makers now use strong, dry sand covering cores exclusively—used after the manner indicated in Figs. 4 and 5. This system of cover cores represents a manifest advance in the art of moulding large gears; it is safe, economical, and expeditious.

Again, not only is it important that the gear founder should have an accurate analytical knowledge of the properties of available moulding sands, in order to formularise suitable mixtures to suit the varying magnitude of the castings to be made; but should be acquainted with the refractory qualities of the various facings on the market; and, if need be, should have a few old-fashioned wrinkles up his

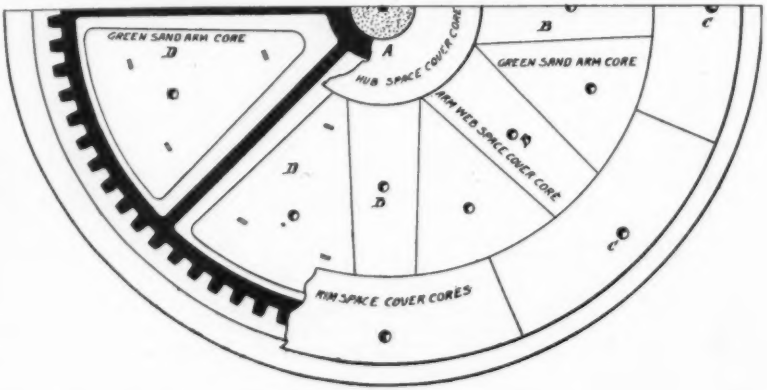


FIG. 5.

HALF PLAN SHOWING GREEN SAND ARM CORES. HALF PLAN SHOWING DRY SAND COVER CORES.

or gum sand; and in no instance was the old trouble repeated, for they adjusted themselves to the shrinkage of the environing metal.

Having described and illustrated the method of forming the teeth moulds, selecting facings, and making the green sand arm cores, we now pass on to the question of covering in. In casting a heavy gear it is important that there should be no strain; the slightest uplift of the cope would cause the width of the face to vary and the gear to run untrue. With this danger in mind the modern gear founder has entirely discarded flexible wooden copes, as they are always liable to twist in lifting and bulge under pressure. Ponderous iron copes have also been abandoned, both on the score of expense and difficulty in handling.

sleeve, to bring out when occasion demands. Well do I remember such an occasion. A heavy casting had been made, with a skin the sight of which was enough to turn one grey with fright. A moulder of the "old school" suggested that a certain proportion of fire clay should be mixed with the facing. It was done, and the skin on the next heavy dynamo field produced was a joy to any moulder who takes a delight in his work.

For a like reason to the foregoing, the maker of machine-moulded gears should have a sound knowledge of metallurgy, so as to be able to select his metals by chemical analysis. The metal for a gear should be as close grained as possible, especially in the teeth, since a skin of fine-grained combined carbon

offers the best wearing surface, yet must not be chilled, as in many cases the shrouds must be turned, hub-bored and key-seated in the machine shop, hence must not be too hard for the tool.

A metal mixture containing 2 to 2.5 per cent. of silicon would be suitable for a gear 1-in. pitch, but would be useless for a gear 7-in. pitch; in which the mixture should contain an average of about 1.25 to 1 per cent. of silicon.

Another condition worth noting is that if the casting is to be sound and the teeth sharply defined, the metal poured into the mould must be *hot*.

With lively metal the gases generated in the mould can be easily expelled, and owing to its fluidity shoots quickly out of the hub, along the arms, into the rim and teeth around the circle, filling every nook and corner in the mould, and producing teeth with the knife edge appearance which the gear moulder likes to see.

An excellent preparation for clearing the metal from scoria and dirt and increasing the chances of clean castings is a flux, a composite powder with a dolomite base, which we made into a paste and spread on top of each charge in the cupola, as well as sprinkled (in powder form) over the bottom and sides of ladle before tapping out the hot metal. This composition causes the metal to boil, throwing the scoria—which is of lighter specific gravity than the iron—up to top of bath as a scum, which is raked off prior to pouring the metal into the mould.

Having described the preliminary mould-forming preparations; *modus operandi* of making the teeth by machine; method of building up the internal structure of the mould with green sand arm cores, and dry sand covering in cores, besides giving some practical data on sands, metal mixtures, etc.; it only remains to add, that in estimating the amount of metal to be used in pouring the casting, at least a ton extra should be provided to flush through after it has once been filled, to ensure the elimination of occluded gases, or to eject any stray dirt which may have flowed in accidentally. To effect this purpose, capacious overflow gates should be provided, and a suitable pig bed made in the foundry floor in close proximity to the mould. It is not necessary to dwell upon the importance of feeding, both around the centre core and in the rim at junction of each arm; but as a final word we would emphasise the wisdom of determining carefully the time of hoisting out the centre core in order to accelerate the cooling of the heavy mass of metal in the hub, and thus adding uniformity of shrinkage. We had a costly experience by neglecting this precaution. A 15-ton gear was poured in the afternoon, and the removal of the core in the early hours of the next morning was left to labourers. They took out the 18-in. hub core before the metal skin was set, hence the hub began to bleed, leaving a huge cavity, and the gear had to be thrown on the scrap heap.

—o—

SOME EFFECTS OF CONTRACTION.

By Alexander Fraser.

The contraction of iron in some castings, and the resulting bends and breaks, are a great source of worry and extra labour, if not thoroughly understood, to both pattern-maker and moulder, especially so to the makers of light castings, as a very slight unequal distribution of weight will cause bends and twists that make most of the castings useless, or nearly so, for cheap and accurate fitting. Some of these may be straightened and put right by paneing, that is, stretching by the hammer, or heating in the fire, but these methods require some skill and time which are not always at the disposal of fitters, where the work is standardised and prices cut as low as possible.

In stove or range work, where there has been very keen competition for some years, the employment of methods for turning out castings more accurate as to size and shape has been very prominent, and it is the latter quality with which we shall deal.

When unequal distribution of weight is mentioned above, it is not meant that a pattern or casting should be of equal thickness over all, but that the weight should be so distributed that the casting would cool in all its parts at the same time, which is called balancing the weight.

There are some castings where it is practical to do this, such as a plain plate, when the centre can be thinned down, or the edges thickened to balance each other, as the latter lose their heat much quicker than the centre. A plate so

balanced would come out of the mould as cast, and would be less liable to be cracked and broken than one three times its weight which has been cast an equal thickness throughout. We are referring, of course, to plates of $\frac{1}{8}$ in. to $\frac{1}{2}$ in. thickness, and from about 18 in long, as when shorter than this the effect of the unequal contractions does not show to any appreciable extent, unless the casting is very light. Balancing to this extent is seldom practical, and then the method resorted to is to make a trial casting from the pattern standing at the shape at which the casting is required, and see how much and in which way the unequal contraction has pulled it. The pattern is then set or cambered with the same amount of bend, or nearly so, in the opposite direction to which the casting has come, or if an iron pattern is required it will, of course, be set with double the amount of bend. This process has the disadvantage of putting great strain on some parts of a casting, which causes it to be easily broken, but it is the best that has been brought forward yet for work of the description named above.

The patterns, in some cases, are made in the shape that the castings are required, and while the latter are hot the sand is stripped of those parts which need cooling more quickly, allowing all the parts to contract at the same time. This does away with the tension, but it is a process which is not generally followed, as few castings lend themselves to it, and when a man has a number cast at the same time, he could not strip all quick enough for that purpose.

The first process mentioned is the one generally followed, as it will be seen that if the pattern-maker knew in which way a casting would bend and pull by his knowledge of its build, he might save some work by setting it before a trial casting was made, and if the build of the pattern is not too intricate, this can be done quite accurately from former observations; but if the pattern is of a complex nature, and the setting is, for the amount of bend wanted, nearly guess work, and does not come quite true, even then there is much less work to do, in most cases, on the dirty block and pattern. To illustrate this, we will suppose a casting is wanted from a perfectly plain plate pattern of equal thickness throughout, size 3 ft. by 1 ft. 6 in. by $\frac{1}{4}$ in. When this casting is taken from the mould, we will find that the sides and ends have a regular circular bend on nearly their full length upwards, towards the top of the mould, quite a quarter of an inch at the centre of the sides, and about an eighth at the ends. These measurements are on the extreme edges of the plate, the bend gradually decreasing as it nears the centre, until at about 4 in. from the edge it disappears altogether and the plate within that 4-in. margin is perfectly flat, being no twist or bend on it.

Now, as to the cause of these bends, which I am sure all pattern-makers and moulders engaged on this class of work have noticed, and which must be thoroughly understood to enable anyone to set a pattern with any degree of accuracy, we will try to explain as simply as possible.

In the first place, the outside edges will cool first, will have taken all their contraction and be set hard, while the centre is still hot, which, therefore, has still to contract, and being tied to the edges, it draws them into a smaller area, bending them, as it cannot decrease their length. One proof that this is the cause of the bends, is to break the casting about the middle of one of its edges, not right across, but nearly to the centre, and then separate the edges of the break by pulling one from the other, which will require some force, but when clear for a few inches inwards, let go, and we will find they overlap one another more at the outside than nearer the centre, which shows that the edge has put a tension on the inner parts, but some of it being relieved by the separation of the edges of the break, those parts attain more nearly their natural position.

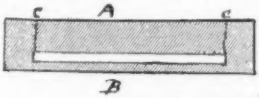
We will now consider a casting with a light centre, meaning one in which the inner parts cool before the edges, for example, a perforated plate, with a solid border. A casting of this kind when taken from the mould would have all the edges perfectly straight, but not parallel, being all warped and twisted, and if the centre is very light in proportion, it would be squeezed upwards, showing that the heavy edges have contracted after the centre had finished doing so, therefore encountering resistance enough to put a great tensile strain on them. Proof of this is seen when the edge is broken, which will spring open and remain so. A casting of this nature is easily broken, and cannot be rectified by setting the pattern, the only way being to add weight to the centre

or taking it out of the border, so that they may cool more equally.

A flange, if of any depth, on a light casting, will turn out a convex shape, if cast from a straight pattern, and, of course, drawing the parts of the casting near, with it. This bend will be the more defined the more the flange is tapered, the cause of this being the outside edge of the flange having cooled first, and the root or junction with the casting still contracting, thereby drawing it into a smaller area.

A flange that is cast downwards in a mould does not cause quite as much bend as one cast upwards, as the extreme edge does not lose its heat so quickly when moulded in this manner.

The severe strain caused by unequal contraction upon some castings has a seemingly curious way of displaying itself, viz., the liability to fracture easily in what appears to be the strongest part of the casting. This can best be explained by the following diagram:—



We will suppose this casting to be 12 in. long, $\frac{1}{8}$ in. thick, $1\frac{1}{2}$ in. wide on A side and two ends, $\frac{1}{2}$ in. on B side, with $\frac{1}{2}$ in. slot.

The side A being warm and still contracting after side B is cool, crushes the latter inwards and causes it to bend slightly, but the strain put upon the casting by this crushing is seen if, when cold, it is given a smart blow with a hammer, it will break, not in the light side, as may be expected, but at either of the lines C C, and the edges of the break will spring open and remain so.

An endeavour has been made in this paper to explain the examples in the most untechnical manner possible, for a thorough understanding of them.

——o——

Mr. T. L. Cunningham and Mr. H. S. Morrison have started business at Moorgate Court, Moorgate Place, London, E.C., as machinery agents and merchants.

Messrs. Cowans, Sheldon & Company are supplying the Admiralty with six cranes for H.M. Dockyard, Devonport, and the firm are also supplying cranes, traversers, etc., to the North British Railway Company.

PIPE FOUNDING.—VI.

By W. E. Cowens.

The plant and machinery having been described, we now consider the important question of cost. The site of the works must be selected with a due regard to the demand in the immediate neighbourhood from gas and water companies. It must also be in close proximity to the railways, canal, or river, so as to secure the advantage of easy rail or water carriage, or preferably both, so that the incoming raw material and the finished pipes can be readily dealt with.

The area required will be considerable, as not only has the question of manufacture to be considered, but also the storage of pipes in the event of the weather stopping deliveries during the progress of a large contract. This contingency is usually allowed for in the specification, and would put the manufacturer to considerable expense and inconvenience if he has no storage room.

Buildings will be required of a substantial character over the pits and to accommodate the power. The bank pipes, cleaning and testing, etc., can be carried out in single storey sheds of cheaper construction.

The plant will comprise:—

Power, which may be steam or electric.

Pumps for testing, and for hydraulic supply for the pipe tests, hydraulic presses for putting up the bottoms and for the cupola hoist.

Two cupolas, with staging and hydraulic hoist.

Blower and pipes for cupolas, preferably two blowers, one being spare.

Cupola weighing machine.

Cranes for the pits, and for blacking and loading.

Two or three pipe testing machines, with air or deadweight accommodation, and a weighing machine.

Two or three pipe lathes for cutting off heads and turning and boring.

Gas producer and gas mains to pits and stoves.

Loam and sand mill.

Small smithy and repairing shop.

Pipe plant, as already described, consisting of boxes, spindles, kellets, patterns, stoves, etc.

The capital required for the above will probably be twelve to fourteen thousand pounds—to equip two pits and banks—and the output about 15,000 tons per annum.

The working costs will include rent, rates and taxes, water, lighting, coal and

coke, blacking, sand, loam, tar and oil for coating, and numberless small stores. There will be two cupolas working alternate days; they should have daily consumption sheets prepared, showing the amount of pig-iron, scrap, coke and limestone used, and on the same sheets the weight of gits and left metal, and the amount of wood and coke used for the bed. Percentages should be made daily, so as to show at once any carelessness in melting, and also to keep the gits and heads as lows as possible. These sheets should show at the foot the cost per ton of the metal melted, the percentage of waste in remelting, the coke and limestone per ton of metal melted, and the cost of the bed, and should be carefully watched to see that no unnecessary waste takes place. To obtain the cupola cost per ton, it is usual to take it over a period of say 12 months, debiting all the items that come against them and dividing by the output in good pipes. Table I. shows such a cost. It must be remembered that this cost depends largely upon the output and on the facilities provided for handling. For instance, if from the selection of the site the metal and coke can be delivered at the level of the charging hole, the hoist is not required, and the double handling of the material is saved, thus considerably reducing the cupola labour. Each case must be taken on its merits.

TABLE I.—*Capital Value say* £800.

	£	s.	d.
Interest, depreciation and repairs, 10 per cent....	80	0	0
Belts for blower	10	0	0
Packing for hoists and stores ...	5	0	0
Cupola tools	25	0	0
Mason's time repairing and relining	110	0	0
Fire bricks, fireclay and ganister	90	0	0
Hard coke at 17s. per ton... ...	1,052	10	0
Fire wood	11	0	0
Limestone	38	10	0
Hydraulic power for hoist ...	35	0	0
Power for blower	50	0	0
Blacking for ladles...	65	0	0
Water for cooling	3	0	0
Wages of cupola men	350	0	0
Oncost charges	175	0	0
	2,010	0	0

Output for the year was taken 8,000 tons.

Then $\frac{2,100}{8,000}$ = 5s. 3d. per ton.

This would probably be reduced to 4s. 6d., or under, if the maximum output had been obtained. The labour at the pits, if carefully arranged, should not exceed 4d. per inch for 12 ft. lengths, and 3¼d. per inch for 9 ft. lengths.

The cleaning and fettling should cost 9d. to 1s. per ton, depending on the size of pipe. Cutting off heads in the lathe 1s. 6d. per ton for small sizes and 1s. per ton for the larger sizes. Testing and weighing about 1s. 3d. per ton. Blacking, including mixture and materials, 1s. 6d. per ton. Loading up 9d. to 1s. per ton.

The loam for the cores and sand for use in the moulds require careful watching. The sand with care can be used over and over again with very little admixture of new. The loam can also be largely used again by pugging over in the loam mill, and a considerable saving can be effected by using a proportion of sand with the loam. Table II. gives a week's test taken at the loam mill, and shows the cost per ton of pugged loam ready for use:—

TABLE II.—*Capital Cost say* £100.

	£	s.	d.
Interest, depreciation and repairs, 10 per cent. per annum, equal say 4s. per week	0	4	0
Engine or electric power	0	15	0
New loam, 6 tons at 4s. 6d. per ton	1	7	0
Old loam used over—cost of wheeling back to the mill 3d. per ton, 9 tons	0	2	3
Sand, 8 tons at 2s. 9d.	1	2	0
Clay, 8¼ tons at 2s. 3d.	0	19	2
Hair, 3 cwt. at 10s. per cwt.	1	10	0
Water, 1,300 gallons at 6d. per 1,000 gallons	0	0	8
Man and lad	1	11	6
Oncost charges...	0	15	9
	8	7	4

Total finished weight produced 38 tons.

$\frac{£8\ 7s.\ 4d.}{38}$ = nearly 4s. 2d. per ton.

The amount used for each size of core can be easily calculated, and the cost ascertained. If straw ropes are used they must also be added.

The cost of the stoves must be taken out in the same manner as the cupola and loam mill, an occasional test being taken over a period of a week to see that no waste is taking place. In taking out such a test the proportionate cost of cleaning out tubes, producer and stoves must be added. It will be found that the cost averages from 5s. to 6s. per ton on the output. The complete form of estimate of cost for bank and pit pipes is shown in Tables III. and IV.:—

TABLE III.—*Estimate for Bank Pipes*

	£	s	d.
Cost of metal per ton			
Waste in re-melting, 5 to 7½ p. c. ...			
Moulding and cores			
Labourage			
Materials and stoves			
Cupola and coke			
Testing			
Cleaning and fettling			
Blacking (if required)			
Loading			
General establishment charges ...			
Delivery			
Cost per ton			
Add for profit			
Selling price per ton			

TABLE IV.—*Estimate for Pit Pipes.*

	£ s. d.
Cost of metal per ton	
Waste in re-melting, 5 to 7½ p. c. ...	
Moulding and cores	
Labourage	
Materials and stoves	
Cupola and coke...	
Cutting off heads in lathe	
Testing	
Cleaning and fettling	
Blacking (if required)	
Loading	
Straw ropes (if used)	
General establishment charges ..	
Delivery	
Cost per ton	
Add for profit	
Selling price per ton	

The general establishment charges are made up of rent, rates, taxes, lighting, management, clerks, draughtsmen, foreman, advertising, travelling and agents' commission etc., in fact, of all items which cannot be directly charged to the work. They are usually computed on the expected output, and allowed in the estimate at per ton of pipes made. The amount should be fixed periodically by the manager, and given to the cost clerk, and they should be checked at least every six months.

In conclusion, it should be taken as a rule that no item of cost is too small for the personal attention of the manager. It is only by strict attention to small details that a profit can be made. The manager should know weekly what new materials are being used, and their cost. Watch closely the coke and limestone used in the cupola, the percentage of left metal, gits and runners, the waste in remelting the percentage of bad pipes and the cause of failure, the cost of cupola repairs and of all labour, and immediately require an explanation for any increase that may occur above the average.

—o—

RUMOURS have been current during the month of a proposed trade agreement in the foundry trade. The leading Scotch and English makers met in conference to discuss the scheme, and the project has been received with favour. A large number of firms have issued circulars advancing prices of light iron castings 10 per cent., and it is believed the adhesion of the remainder will be obtained. Another result of the meetings is that the English Light Castings Association and the Scotch Light Castings Association have agreed to unite for a time under the title of the United Kingdom Light Castings Association.

COMBINED INFLUENCE OF CERTAIN ELEMENTS OF CAST IRON.*

BY ARTHUR H. HIORNS.

THE object of the present research was to ascertain the combined influence of two elements when simultaneously present in highly carburised iron. Each alloy was made to contain only two elements in addition to iron and carbon, and each may be considered as pure with regard to the specific elements introduced. Each series contains the constituents in three different proportions, so as to give each in its turn a dominant, an equal and a subordinate influence as regards the quantity present. The following percentages in the accompanying ratios were taken :—2 : 2, 2 : 1, 1 : 2.

Manganese and Silicon.

A weighed quantity of pure cast iron was embedded in charcoal in a carbon crucible and manganese and silicon added so as to yield a cast iron containing 2 per cent. of manganese and 2 per cent. of silicon. The whole was then melted in a furnace and kept for an hour in a fused state, so as to enable the alloy, if possible, to take up additional carbon. The whole was then transferred to a muffle furnace and maintained at a temperature of about 1,100 degrees C. for several hours in order to facilitate any separation of carbon in the form of graphite. If cast iron, which in the liquid state contains carbon wholly in solution, is kept for a sufficient time somewhat below a temperature of 1,130 degrees C., the carbon, in the absence of interfering elements, will separate out of solution in the form of graphite in large flaky crystals. Silicon, if it does not facilitate the separation of graphite, does not prevent such separation. On the other hand, manganese acts as a check on such separation, so that it may be safely assumed that these two elements, silicon and manganese, tend to neutralise each other, and it is only a question of the proportion of each requisite for neutralisation. With the above percentages the silicon more than neutralises the effect of the manganese. If the whole of the manganese is chemically united with the silicon to form the compound MnSi., the proportion of

* Abstract of Paper read before the Staffordshire Iron and Steel Institute.

each would be about 2 : 1, leaving an excess of silicon to unite with the iron.

Fig. 1 shows the microstructure of the alloy with 2 per cent. of manganese and 2 per cent. of silicon. The graphite has separated in moderately large flakes and the iron matrix contains some free carbide of iron, or the double carbide of iron and manganese, but the main mass of the matrix is iron with possibly some manganese in solid solution forming a structureless mass.

FIG. 1.
MANGANESE 2 PER CENT.
SILICON 2 PER CENT.

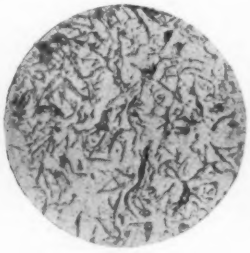


FIG. 2
MANGANESE 2 PER CENT.
SILICON 1 PER CENT.

FIG. 3.
MANGANESE 1 PER CENT.
SILICON 2 PER CENT.

Another sample of cast iron was prepared so as to contain 2 per cent. of manganese and 1 per cent. of silicon. The same conditions as before were strictly adhered to, in order to make the results precisely comparable. The result is shown in the micro-section, Fig. 2.

It will be observed here that while a portion of the manganese is neutralised by the silicon, there is a certain proportion of free carbide. The flakes of graphite are smaller in quantity and less in size. Evidently there has been a strong contention between the tendency of manganese to keep the carbon in solution and that of silicon, added to the influence of time and temperature, in inducing the separation of graphite. Much of the matrix is structureless, and probably contains the excess of manganese in solid solution. Now while at the temperature of the experiment graphite separated out, it only required a moderately rapid lowering of the temperature below the graphite-forming range for the carbon to be kept in solution, that is, for the manganese to play its natural *rôle*.

Another alloy was prepared under precisely the same conditions as in the other cases, in the proportion of 1 per cent. of manganese and 2 per cent. of silicon, with the result shown in Fig. 3. It will be observed that the flakes of graphite are very large, and occupy a considerable portion of the surface. The matrix is largely structureless, and there is an absence of free cementite. Assuming as before that the manganese is wholly combined with the silicon to form the

FIG. 4.
MANGANESE 2 PER CENT.
PHOSPHORUS 2 PER CENT.

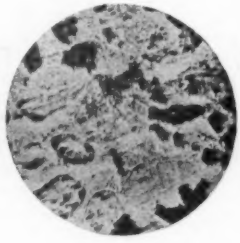


FIG. 5.
MANGANESE 2 PER CENT.
PHOSPHORUS 1 PER CENT.

FIG. 6
MANGANESE 1 PER CENT.
PHOSPHORUS 2 PER CENT.

compound MnSi., there would be no free manganese to unite with the iron, or to combine with the carbon to form carbide, therefore the excess of silicon would combine with the iron, leaving the carbon free and unrestrained to separate out as graphite at the temperature of the experiment.

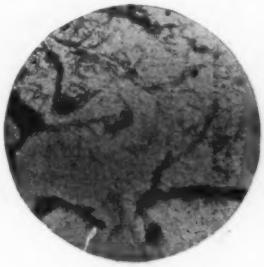


FIG. 7.
MANGANESE 2 PER CENT.
SULPHUR 2 PER CENT.

FIG. 8.
MANGANESE 2 PER CENT.
SULPHUR 1 PER CENT.

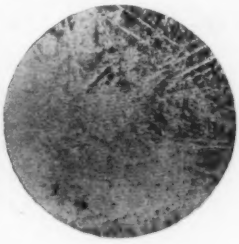


FIG. 9.
MANGANESE 1 PER CENT.
SULPHUR 2 PER CENT.

These three experiments go to prove that manganese and silicon in cast iron tend to neutralise each other. They form strong presumptive evidence of the union of manganese with silicon in the proportion of 55 to 28 forming the compound MnSi., for if a higher proportion of silicon than this united with manganese there could be no free cementite in the alloys shown in Figs. 1 and 2. On the other hand, if a slower silicide were formed, the matrix of Fig. 3 would not be likely to be structureless. It follows from these conclusions that 28 parts of silicon will neutralise 55 parts of manganese, which is nearly in the proportion of 1 to 2. But in the case of No. 1, although there is an excess of silicon, it has not prevented some hard structureless constituent being separated from the matrix, which may be silicide of manganese.

Manganese and Phosphorus.

Three samples of pure cast iron were next prepared, and manganese and phosphorus added in the proportions of 2: 2, 2 : 1, and 1: 2, as in the case of silicon and manganese. The conditions of preparation and mode of heating and cooling were the same as in the previous alloys. The phosphorus was obtained from a specially prepared rich alloy of iron and phosphorus.

The alloy with 2 per cent. manganese and 2 per cent. of phosphorus is not uniform in composition, the three chief components being irregularly distributed, namely, pearlite, cementite, and phosphorus eutectic. The different components are very clearly shown by submitting the section to the method of heat tinting. This consists of exposing the metal to a temperature sufficient to

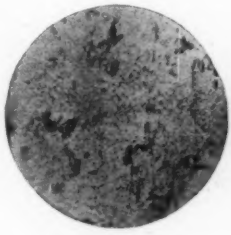


FIG. 10.
SILICON 2 PER CENT.
SULPHUR 2 PER CENT.

FIG. 11.
SILICON 2 PER CENT.
SULPHUR 1 PER CENT.

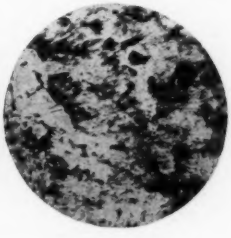


FIG. 12.
SILICON 1 PER CENT.
SULPHUR 2 PER CENT.

bring out the temper colours or oxidation films. The pearlite is seen to partake of a deeper hue than the cementite or the phosphorus eutectic.

In Fig. 4 the light wavy portion is probably a double carbide of iron and manganese, having the formula

FIG. 13.
SILICON 2 PER CENT.
PHOSPHORUS 2 PER CENT.

FIG. 14.
SILICON 2 PER CENT.
PHOSPHORUS 1 PER CENT.

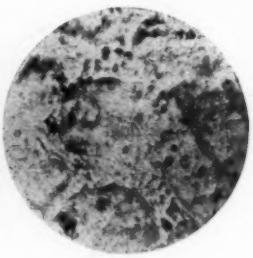


FIG. 15.
SILICON 1 PER CENT.
PHOSPHORUS 2 PER CENT.

$(Fe\ Mn)_3\ C$. The darker net-like masses contain most of the phosphorus in the form of a eutectic mixture and the dark groundwork is pearlite. In addition to the above-mentioned constituents there are a few small flakes of graphite running through the pearlite areas. The manganese has very largely prevented the separation of carbon as graphite, and therefore the carbon has remained partly in solution in the iron and partly in combination with the iron, or iron and manganese, as cementite. The phosphorus has combined with the iron to form a phosphide, which is hard, white, and moderately fusible, so that it remains liquid after the general mass has solidified, and the phosphorus eutectic is the last component to solidify. This circumstance, together with its unequal distribution and the innate brittleness of the phosphide Fe_3P., readily accounts for the brittleness of phosphoric cast iron.

Another sample of cast iron was prepared, Fig. 5, containing 2 per cent. of manganese and 1 per cent. of phosphorus. The structure is somewhat similar to the preceding one, but the amount of phosphorus eutectic is less; the pearlite is also in quantity and the amount of structureless cementite is much more pronounced. This indicates a harder iron. Graphite in the form of flakes is absent. The cementite is probably a double carbide of iron and manganese, since there is no free iron to dissolve the manganese and form a solid solution.

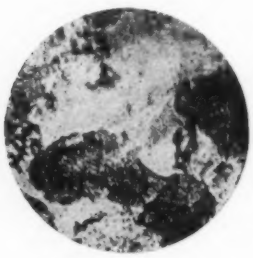


FIG. 16.
PHOSPHORUS 2 PER CENT.
SULPHUR 2 PER CENT.

FIG. 17.
PHOSPHORUS 2 PER CENT.
SULPHUR 1 PER CENT.

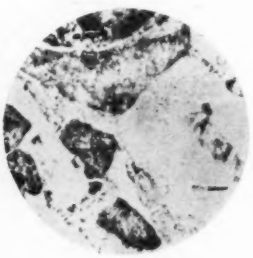


FIG. 18.
PHOSPHORUS 1 PER CENT.
SULPHUR 2 PER CENT.

A third sample was next prepared, containing 1 per cent. of manganese and 2 per cent. of phosphorus. This alloy differs considerably from the preceding ones in containing a large proportion of

graphite and in the absence of plates of structureless cementite. The phosphorus eutectic occupies a large part of the surface, surrounding areas of pearlite, and running through the pearlite are flakes of graphite. The manganese must be largely in the pearlite, which therefore consists of ferrite from which the graphite has separated, and cementite, made up of the double carbide of iron and manganese. A micro-section of this alloy is shown in Fig. 6.

According to Stead, who is perhaps the greatest authority on the action of phosphorus on iron, phosphorus does not influence the condition of carbon, either to cause it to separate as graphite or to keep it in the combined form; while manganese has a very decided influence in preventing the separation of carbon as graphite. If, then, phosphorus is neutral in its action, the manganese present must tend to prevent the formation of graphite. But in the present alloy a fair proportion of graphite is in evidence, therefore 1 per cent. of manganese is insufficient to prevent some graphite separating out, and this is due to the influence of the long-sustained high temperature at which the alloy was kept. It should be stated that the graphite is segregated in certain parts, while the greater portion of the meta[1] is free from graphite. This will be readily seen by reference to Fig. 6.

Manganese and Sulphur.

Both manganese and sulphur act in the same way as regards their influence on the condition of carbon on cast iron, and when each element is separately present the carbon tends to remain in the combined form, the separation of graphite being prevented. Manganese itself combines with carbon and increases the quantity of total carbon the iron is capable of retaining. Sulphur also unites with the oxygen of the air to form sulphur dioxide when the air has access to the metal, so that the sulphur is partly removed by volatilisation, and causes the metal to present a honeycombed structure, due to blow-holes. But sulphur also unites with the iron to form sulphide of iron, and may then be retained as a solid substance. This sulphide of iron is unstable at high temperatures, and the liberated sulphur tends to escape as a gaseous compound. But much of the sulphur is retained and assists in keeping the carbon in the combined form.

With the simultaneous presence of manganese and sulphur the latter combines with the manganese in preference to the iron, and as this manganese sulphide has a high melting and high dissociation point, the sulphur is not liberated in the gaseous form, and blow-holes and red-shortness are largely prevented. In cast iron containing sulphur and manganese we may have both sulphide of iron and sulphide of manganese present, the former of which induces the retention of combined carbon, while the latter seems to be largely neutral, hence we have the anomaly of two elements present in cast iron, each of which separately induces combined carbon, but when combined have practically no influence on the condition of the carbon, so that the influence of time and temperature can play their accustomed *rôle*.

Now, as the melting point of sulphide of manganese, as proved by Chatelier, is superior to that of iron, and very much superior to that of sulphide of iron, it follows that in a cooling liquid mass of cast iron the sulphide of manganese is the first to crystallise out, leaving the iron and carbon free to assume their accustomed forms, hence the favourable action of manganese on iron containing sulphur. The hurtful influence of sulphide of iron is due, on the contrary, to the fact that, being the constituent to solidify last, it segregates between the grains and thus breaks the continuity of the mass.

Three samples of cast iron with manganese and sulphur were prepared in the same proportions as in the previous experiments. Fig. 7 is the alloy made to contain 2 per cent. of manganese and 2 per cent. of sulphur. The dark portions show the sulphide of manganese forming the larger patches and the flakes of graphite the smaller and lighter ones. The lighter portion consists of pearlite with a little free cementite. The alloy with 2 per cent. of manganese and 1 per cent. of sulphur (Fig. 8) contains manganese in excess, but the structure is much the same as the preceding one, the manganese sulphide being more pronounced. Fig. 9 contains 1 per cent. of manganese and 2 per cent. of sulphur, so that the sulphur is in considerable excess. The manganese sulphide is distributed in patches over the surface, but there is no graphite visible, and analysis showed its absence. The structure consists mainly of pearlite having well-defined boundaries of cementite, and some needle-shaped grains of cementite across

the pearlite. There are also frequent blow-holes, showing the influence of decomposed sulphide of iron.

The above three alloys were made to contain the proportions mentioned, but some sulphur volatilised, and the result of analyses for Figs. 7 and 9 gave 1.53 and 1.43 per cent., while that of Fig. 8 showed no less.

Silicon and Sulphur.

Silicon tends to the separation of graphite from cast iron, while the influence of sulphur is in the opposite direction, indicating what is termed combined carbon. But silicon and sulphur may unite to form the compound SiS_2, in the form of white needle-shaped crystals, which may be volatilised in a stream of gas, so that gaseous compounds of sulphur may remove the silicon and sulphur. The effect of sulphur is much more powerful than that of silicon, so that in these alloys very little graphite might be expected to be formed, and such is really the case. The structure is very confused, and in each case it is difficult to get more than a small area free from blow-holes. As the effect of sulphur is to produce combined carbon, we should naturally expect to get a quantity of cementite. The constituents, therefore, appear to be cementite, pearlite, sulphide of iron, and a little graphite. All these are mixed together without any definite arrangement, and interspersed with frequent blow-holes.

Three alloys were made in the same proportions as in the former alloys, but in each case some of the sulphur must have passed off in the gaseous form. Fig. 10 was made to contain 2 per cent. of silicon and 2 per cent. of sulphur. The structure is very fine, containing pearlite, some massive cementite, some patches of sulphide of iron, and many blow-holes. Graphite is also present, but in a very divided state. The alloy containing 2 per cent. of silicon and 1 per cent. of sulphur is similar to the preceding alloy, but the pearlite is well developed, and the metal is full of blow-holes, as shown in Fig. 11. The sample with 1 per cent. of silicon and 2 per cent. of sulphur is whiter, harder, and contains much more massive cementite. It is full of blow-holes, as shown in Fig. 12. Pearlite is also well developed. Here the influence of the high soaking temperature and slow cooling in allowing the graphite to separate out is counterbalanced by the influence of sulphur, and while some graphite is present it is in a too fine state of division to be evident in the micro-section. Analysis showed no diminution in the sulphur, but this may be due to the difficulty of obtaining an average sample owing to the unequal distribution of the sulphide.

Phosphorus and Silicon.

Alloys containing these elements in three different proportions were prepared in the same way as in the other alloys. Phosphorus does not appear to have any strong tendency to modify the condition of the carbon in cast iron, while silicon probably has an influence in preventing super-cooling and thus promotes the stable condition, that is, it lowers the temperature at which graphite can be separated. Here, then, we have two elements, one of which can be considered neutral, and the other active with regard to the separation of graphite. Hence the effect of time and temperature can come fully into play, and the carbon, since it does not combine with the silicon or the phosphorus, both of which are united with the iron, can separate out as graphite under the right conditions of time and temperature. The phosphorus combines with the iron to form a hard and brittle phosphide, which is white in colour, and has a comparatively low melting point. It also lowers the amount of total carbon in the iron. On the other hand the silicon combines with the iron and does not seriously harden it or make it brittle unless when present in larger quantity than in the case of these experiments. This silicon iron alloy has a high melting point. It follows from this that the silicon iron alloy is the first constituent to solidify when the iron is cooled down from the liquid state, leaving the phosphide of iron still fluid. This phosphide solidifies last, and forms a complex eutectic mixture with the iron and carbide. The fractured surface of cast iron containing silicon and phosphorus when slowly cooled is mottled, because of the mixture of crystals of eutectic—iron and graphite. Owing to the power of phosphorus to reduce the amount of total carbon, the quantity of graphite will be limited.

Fig. 13 shows the alloy containing 2 per cent. of silicon and 2 per cent. of phosphorus. There is little free ferrite, the matrix being chiefly pearlite. The graphite in some parts is in the midst of a mass of ferrite and in others in the

pearlite. The phosphorus eutectic is fairly regularly distributed through the mass.

The alloy with 2 per cent. of silicon and 1 per cent. of phosphorus is shown in Fig. 14. It differs from Fig. 13 in the much greater portion of ferrite and graphite, the smaller proportion of phosphorus eutectic, and the smaller proportion of pearlite. The quantity of total carbon is greater and the smaller proportion of phosphorus has evidently reduced the quantity of cementite, hence the small quantity of pearlite. This would indicate that phosphorus has a tendency to cause carbon to remain in the combined form, but the strength of this tendency is somewhat feeble.

A third alloy was made to contain 1 per cent. of silicon and 2 per cent. of phosphorus. In this case only three constituents appear to be present. There is no free ferrite. The matrix is all pearlite and the graphite is found in the pearlite. The phosphorus eutectic is very abundant and in large masses, as shown in Fig. 15.

Phosphorus and Sulphur.

Cast iron containing phosphorus and sulphur was prepared in the same way as in the preceding alloys and the same precautions taken as regards temperature and mode of cooling. The effect of phosphorus on the condition of the carbon has been fully discussed in connection with the previous alloys, and the same remarks apply to sulphur. The influence of both elements in the present alloys is strongly marked, and the particular structure induced by each is clearly indicated in the micro-structure. The cast iron is white, hard, brittle, and friable. It is difficult to conceive what possible use could be made of such iron in the foundry unless it be the ease with which a pig could be broken and crushed. The carbon is entirely in the combined form, and there is no trace of graphite. The phosphorus eutectic is arranged parallel with bands of structureless cementite. The matrix is composed of well-formed pearlite, but one cannot explain how ferrite could exist in pearlite in such alloys as these.

Fig. 16 is the alloy made to contain 2 per cent. of phosphorus and 2 per cent. of sulphur. Blow-holes are abundant, both large and small. Wide bands of cementite occur in all parts, and in each case the phosphorus compound is arranged parallel with it, having its usual net-like structure. The matrix is made up of well-developed pearlite.

The alloy with 2 per cent. of phosphorus and 1 per cent. of sulphur has practically the same structure as the preceding, but the phosphorus eutectic is in much greater quantity; see Fig. 17.

The alloy with 1 per cent. of phosphorus and 2 per cent. of sulphur, Fig. 18, has also the same general structure, but the massive structureless cementite is very abundant, and the phosphorus eutectic less in quantity.

On analysis the sulphur in the 2 per cent. alloy was found to have lost 0.18 per cent., and in the 1 per cent. alloy 0.2 per cent.

Discussion.

A brief discussion arose over the contents of the paper.

Mr. J. Hall expressed the opinion that whilst it was for a period possible to work by rule of thumb, as illustrated by the experiments enumerated in the lecture, in the making of iron, it was quite impossible to do so in the making of steel. In the making of steel they were compelled to adopt a system of analysis. He thought the presence of sulphur in cast iron could best be traced through the latter medium.

Mr. Foster suggested that the presence of air might tend to remove the sulphur which, as the lecturer pointed out, if present, might produce blow-holes and fractures, and generally tended to weaken the strength of cast iron. He thought air might mitigate that to some effect.

Mr. Fletcher (Sheffield) also was inclined to the belief that analysis was the surer way. The high temperatures at which iron was melted now in the hot blast furnaces had a great deal to do with the "hit and miss" fractures they now found in iron.

Mr. Hiorns, in reply, thought the experiments he had enumerated were very useful. Of course, his results were only true for the conditions under which these experiments were carried out. The knowledge of the position of the different substances was of the greatest importance in large castings, because if they failed a great loss would be sustained. He had, therefore, undertaken in his laboratory what would be likely to happen in a large works. In regard to the presence of sulphur he had introduced 2 per cent. of sulphur into the cast iron and excluded the air. He found there was little loss, but when air was present he found there was a great loss.

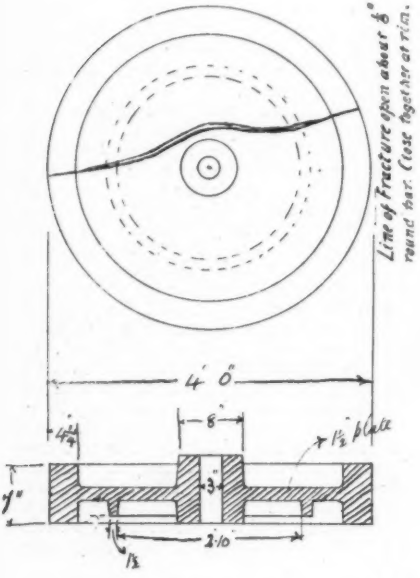
CORRESPONDENCE.

CONTRACTION.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—The subject of contraction is one that touches all makers of castings very nearly. Its force is so tremendous, and the lines along which it acts are in many cases so difficult to determine, that I feel sure any discussion upon a particular case would interest all your readers.

The following is an instance which came



under my own observation quite recently. I do not say that it presents any very great difficulties, but at the same time I know that diametrically opposite opinions are held concerning the cause of fracture and its remedy.

The case is that of a plate-arm fly-wheel fracturing by contraction while yet in the sand. I append a rough sketch, giving the main dimensions. The wheel weighs about 15 cwts., and was cast as shown in the section view. The rim was "bared" on the top and outside about one and a half hours after casting, the plate and boss being kept covered with sand. The wheel was cast about 3 o'clock in the afternoon, and it broke with a loud report in two pieces before being lifted next morning about 10.30. On feeling the heat of rim and boss, it was found the latter was warmer to the touch.

The broken pieces were then taken out, and the larger part placed on its edge, the smaller portion being lifted into its place so as to bring the broken edges together. It was then seen that the broken faces were close together at the rim, and were about ⅛ in. apart round the boss.

This states the case, and I am sure any opinion offered as to the cause of fracture and its remedy would be of interest.

Of course, as founders, we have nothing to do with design, but are simply told to make castings from patterns—no matter how unequally they may be constructed.

Perhaps this letter will bring forth more interesting and complex cases of contraction from other of your correspondents and be of use to our trade generally.

Yours truly,

"CONTRACTOR."

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I note in your issue of December "Subscriber" asks how crucible steel castings can be made in a brass foundry? I think if your correspondent would place himself in correspondence with Philibert Altenbach, of Brighouse, Yorks., he would, perhaps, be able to assist him.

Yours, etc.,

"ANOTHER SUBSCRIBER."

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—In reply to your correspondent, "Eagle," there are a variety of causes for scabs, also a variety of cures. The main cause is, of course, the obstruction of the gases, which may be caused by the sand being too strong for the purpose, or by being rammed too hard. And sometimes too much time has been taken in smoothing. Give a man his own time, and he will make a nice looking mould, to the detriment of the casting. They will smooth and smooth until there is no possible chance for the air to get away, and the only explanation that can be given by the man is: "I vented it well." The class of casting mentioned is one calling for special treatment. The inside

of the trough should not be rammed at all; merely well trodden. Afterwards it should be well vented, and there should be no smoothing of the inside; merely pricked with small vent wire immediately under the runner. Sand for this class of casting should be very open. Old sand from the floor, with a little dry horse manure sieved in, in the proportion of 1 in 20, is plenty strong enough. Some foremen insist on laying a cinder bed under the box, but this is unnecessary in this case, providing you have a good connection with vent wire under the box, because, as a rule, these troughs are only light, and before the vent is choked by falling of dry sand, the casting is set.

Yours, etc.,

THOS. WALKER,
Foreman,

Parkinson & Son, Shipley, Yorks.

——o——

A GRAVITY MOULDING MACHINE

A MOULDING machine which is unique in that it packs the sand in the flask by gravity instead of by a pneumatic or mechanical ramming is being placed on the market by the Mitchell-Parks Manufacturing Company, St. Louis, U.S.A. The machine complete is illustrated in Fig. 1. It comprises essentially two chain belts suspended from a pair of sprocket wheels located about 15 ft. above the floor level. These chains carry buckets which descend into a boot below the floor and are there loaded with sand. The sand is then elevated, being compressed in the buckets by an automatic rammer during its ascent, and dropped a distance of about 12 ft. from the top of the elevator to the flasks. The details of the machine are shown in the line drawings, Figs. 2 and 3. As will be noted, the flask is carried on a swinging cradle suspended from the same beams carrying the sprocket wheels shaft. This cradle can be rocked back and forth, in order to insure an even distribution of the sand as it falls from the elevator. It is also capable of being raised and lowered in order to discharge the completed mould. Directly below the floor underneath the flask is a hopper covered over with a shaking riddle. Sand is shovelled into this riddle, and thence discharged into the hopper, from whence it is fed to the elevator buckets by a feed roll. As each bucket passes the floor level, it comes in contact with an automatic rammer, which compresses the sand in each bucket, so that it will not disintegrate in falling, but will descend in a solid mass of sufficient body to pack firmly around the pattern and to also ram the sand below it. These bodies of sand are thrown from the elevator buckets as they turn over the head sprockets.

When the flask has been filled, a strike-off, shown in the illustration, is drawn down into position and scrapes the sand

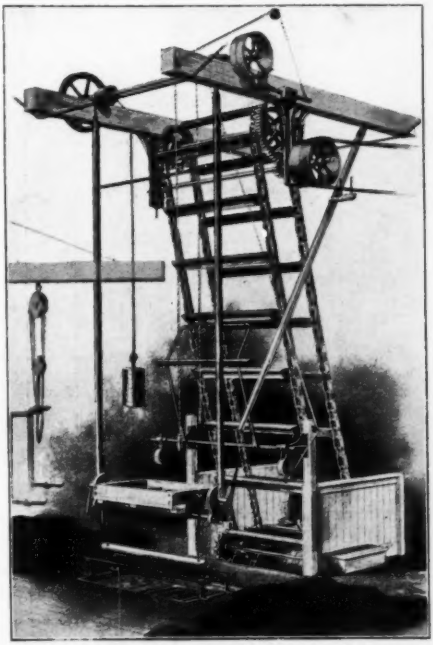


FIG. 1.—THE GRAVITY MOULDING MACHINE.

off even with the edge of the flask. The flask is then fastened firmly to the cradle by means of the clamp shown, and turned upside down, and the cradle lowered, the flask being deposited upon the supporting rails directly under the cradle.

Each half of the pattern is attached to a match-board fastened to the cradle. After the flask has been deposited on the supporting rails, the cradle is drawn vertically upwards, thus withdrawing the pattern from the mould. The cradle is then raised to its working position, another flask is placed on it, and the operation repeated.

The machine is installed in the centre of a floor space large enough to contain the entire output of the machine for one day. This floor space is served by means of two jib cranes situated as shown in the plan view Fig. 4. Two labourers and one operator are usually required for the machine; the labourers to shovel the sand into the hopper, to bring flasks to the machine, and to remove the completed mould. The sand should be tempered at night and arranged in piles on each side of the machine.

64 in., and will handle any ordinary depth of flask not exceeding 18 in. The space occupied by the different sizes of machines is the same in all dimensions, excepting width, all sizes being about 15 ft. from the top of the elevator to the floor. The distance which the sand falls from the top of the elevator to the flasks in all cases is 12 ft. The firmness of the moulds is regulated by adjusting the automatic compressor, and by increasing or decreasing the tension on it, so as to pack the sand in the buckets with greater

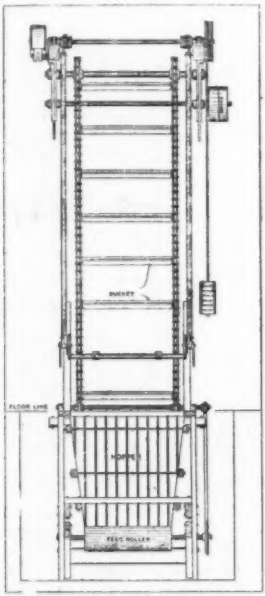


FIG. 2.—END ELEVATION OF GRAVITY MOULDING MACHINE.

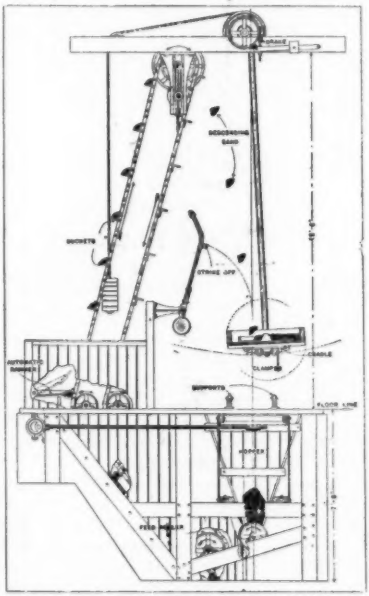


FIG. 3.—SIDE ELEVATION OF GRAVITY MOULDING MACHINE.

For making copes, special bails are used on the cranes, as shown in the illustration, Fig. 1, by means of which the flask can be turned and placed in position on top of the drag. Bottom-boards are clamped on the drags before they are turned in the cradle, and are carried away from the machine with the flask for the purpose of supporting the sand. The cope flasks have special bars which hold the sand in place without the use of bottom-boards.

The machine is built in a varying number of sizes, ranging in capacity from a flask 22 in. by 30 in. up to 48 in. by

or less firmness. It is stated that the pressure of the rammer can be adjusted so as to pack the moulds much harder than they are ordinarily rammed up by hand. It is also claimed that one unskilled workman can operate this machine with but little practice, and that its capacity is equal to about eight hand moulders. The lumps of sand drop from the buckets into the flask at the rate of over 50 a minute, thus filling a large size flask in a very short time. No stripping plates are required, and the machine can be rapidly changed from one pattern to another.

THE PROPERTIES OF ALLOYS OF ALUMINIUM AND COPPER.*

By H. C. H. Carpenter, M.A., Ph.D., and C. A. Edwards.

The research has been carried out by the authors with the co-operation of the Broughton Copper Company, Manchester, and the British Aluminium Company, Milton. More than 1,000 tests have been made, exclusive of about 200 specimens that have been microscopically examined and photographed. The results are classified in the various sections of this report, and every care has been taken to render them accessible and clear.

The following abstract has been prepared to enable readers to obtain a general idea of the main conclusions arrived at without having to study the entire text.

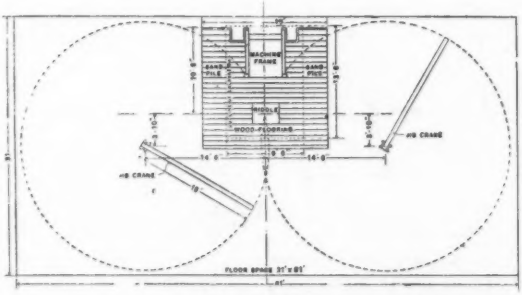


Fig. 4.—Arrangement of Floor Space for Gravity Moulding Machine.

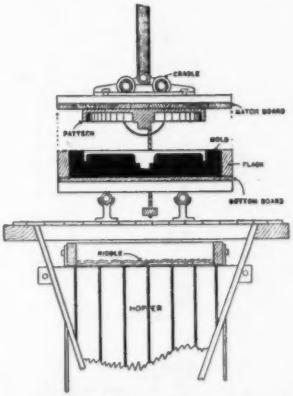


Fig. 5.—Withdrawing the Pattern on Gravity Moulding Machine.

Preparation of the Alloys.

The authors think that the following conclusions may be drawn from the results of their experiments :—

1. There is no need to melt the alloys rich in copper in order to obtain thorough mixing, obviate brittleness, and secure the best mechanical properties. With due care the first cast is as likely to be as good as any that may follow it. Such differences in properties as have been found are probably to be ascribed to accidental variations in the conditions of preparation, of which probably the most important are variations in casting temperatures, and small holes in the castings. This conclusion is not intended to apply to other than small castings. In large castings the difficulties of securing thorough mixing are much greater. In such cases remelting may always constitute the best practical method of ensuring homogeneity of material.

2. Copper-rich alloys can be perfectly satisfactorily prepared from the pure metals, and no advantage is gained by using the 50 per cent. alloy instead of aluminium. The alloys described subsequently have been prepared, some of them from the pure metals, others from copper and the 50 per cent. alloy. The continuity of properties that has been found in the various members of a series constitutes additional evidence that the alloys may be satisfactorily prepared by either method.

3. Alloys rich in aluminium can also be satisfactorily made with only one melting. This conclusion is intended to apply only to small castings. It has been the authors' experience during the research that it is far more important to cast these alloys at the right temperature than to remelt, in order to get the best mechanical properties.

As will be shown later, it was unnecessary to test the influence of remelting on the properties of alloys of intermediate composition. The research has thoroughly confirmed Mons. L. Guillet's

* From the Report of the Alloys Committee to the Institution of Mechanical Engineers.

conclusion that only the alloys at the extreme ends of the series are of any industrial promise.

Accordingly, all the alloys subsequently prepared were melted only once. The greatest care was paid to the two important points (*a*) casting temperature; (*b*) thorough stirring.

Measurements of the total linear contraction of castings on cooling from the freezing-point to the ordinary temperature showed:—

(*a*) That these vary between 1.83 and 2.34 per cent. among the rich-copper alloys:

(*b*) That a uniform value of 1.66 per cent. holds for the rich-aluminium alloys (0-3.76 per cent. copper).

the addition of aluminium between 8 and 13 per cent.

3. The specific-gravity curve of the sand castings exhibits a general similarity to those of the chill castings and rolled bars, but is less regular. Up to 7 per cent. of aluminium the specific gravity values are either equal to or, in most cases, are lower than those of the chill and bars. Within this range the alloys are homogeneous, and appear to consist of a solid solution of aluminium in copper. Beyond, and as far as 10.8 per cent., they are higher. In this range the structure is duplex, and the alloy consists of at least two structural constituents. Denser alloys are obtained by the slow than the quick cooling of these

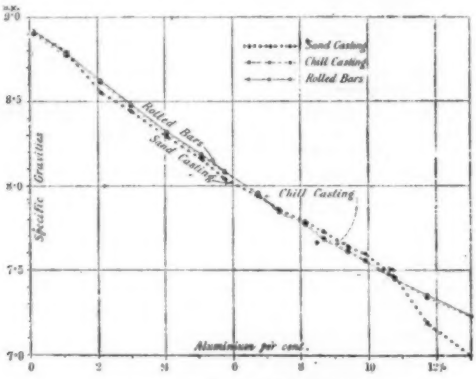


FIG. 1.—SPECIFIC GRAVITIES.

Properties of the Rich Copper Alloys (Specific Gravities).

Attention is directed to the following features of the results:—

1. The chill castings and rolled bars have the same specific gravity. Certain of the alloys have practically the same structures in the two conditions, while in others a similarity exists. In these cases an identity and similarity respectively of specific gravities is natural. But no such structural similarities exist between the chill castings and rolled bars of alloys up to 7 per cent. of aluminium.

2. With the introduction and addition of aluminium up to 13 per cent. the specific gravity drops regularly, and a smooth curve results, as seen in Fig. 1. This fact is of importance, because very marked structural changes are caused by two constituents. Beyond 11 per cent. there is a further structural change, and the sand castings are no longer sound. This is the principal factor in causing the apparently rapid fall of specific gravity at this point.

4. 8.90, the specific gravity of the sand and chill castings of the alloy containing 0.1 per cent. of aluminium, is the standard specific gravity for copper conductors adopted by the Sub-Committee on Cables of the Engineering Standards Committee.

Tensile Tests.

In considering these results as a whole, attention may be directed to the following features:—

(*a*) The limit of industrially-serviceable alloys must be placed at 11 per cent. of aluminium. For most purposes the limit

might be put at 10 per cent., beyond which there is a rapid fall of ductility with no rise of ultimate stress. It will be noticed, however, particularly in the castings, that the yield-point is usually decidedly better at 11 than 10 per cent.

(*b*) Between these limits the alloys fall into two classes:—(1) Those containing from 0 to 7.35 per cent. of aluminium: (2) those containing from 8 to 11 per cent. of aluminium.

Class I. represents material of apparently low yield-point and moderate ultimate stress, but of very good ductility. The introduction and further addition of aluminium causes a gradual increase of strength, but hardly affects the ductility. It is true that as regards the steadiness of the ductility this has only been established for the rolled bars. But the sand and chilled castings have shown the same kind of variations as the rolled bars in all the properties examined, and it appears legitimate to draw this conclusion for them also. This class is not very sensitive to heat-treatment, but is much improved by mechanical work.

In Class 2 come alloys of relatively low yield-point, but good ultimate stress. From 8 to 10 per cent. of aluminium, the ductility is also good. Certain alloys in this class are very sensitive to heat-treatment, but one of them is remarkably indifferent to hot rolling (No. 13).

(*c*) Taken as a whole, the chill are superior to the sand castings, and are themselves surpassed by the rolled bars. Alloy No. 13, and to a less extent No. 12, constitute a notable exception to this generalisation.

(*d*) One of the most noteworthy characteristics of the alloys, as a whole, is their low yield-point, absolutely and relatively. Accordingly the elastic ratio of an alloy of given ultimate stress is low compared with that of a steel of the same ultimate stress. Thus, No. 13 (with 10 per cent. of aluminium), with an ultimate stress of 38 tons per square inch, has an elastic ratio of only 0.39, whereas that of a Swedish Bessemer steel, containing about 0.35 per cent. of carbon of the same ultimate stress, is 0.68. This appears to place these alloys in a position of inferiority. But it has been shown recently by Messrs. Stanton & Bairstow that the primitive yield-point of a steel is usually an artificial figure, and is due to a stiffening caused by mechanical treatment in preparation. Thus, they found that the proper yield-point of the Bessemer steel mentioned was 15.2 tons per square inch. The elastic ratio then became 0.40, which is identical with that of No. 13. These rich copper alloys do not show anything like the same tendency to assume an artificial yield-point. The inferiority of the aluminium bronzes is thus only apparent, not real.

(*e*) Cold-drawing raises the elastic ratio to a very high figure, and leaves a

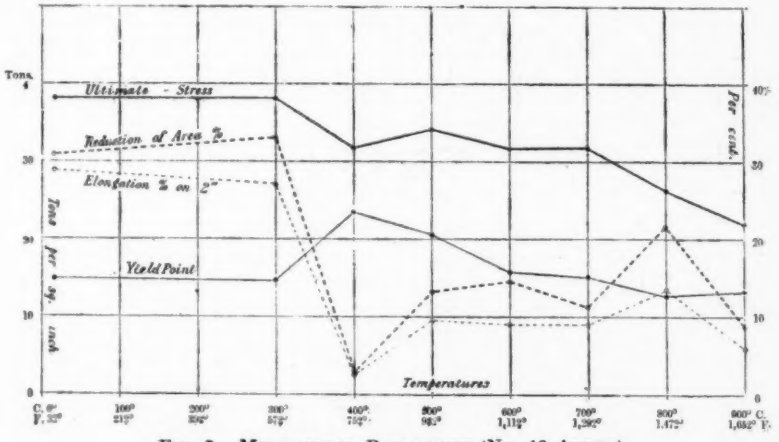


FIG. 2.—MECHANICAL PROPERTIES (NO. 13 ALLOY)

considerable measure of ductility, but it has not been successful at about 5 per cent. of aluminium, where a tendency to pipe has been noticed.

(*f*) Another striking feature of the mechanical qualities of the alloys is the very high ductility, which is almost constant between 0 and 7.35 per cent. of aluminium. More especially is this the case with the reduction of area. The values obtained were so much superior to those given in the best results found in the literature that the authors became suspicious of their results. It was accordingly decided to obtain an exact copper blank of the series. At their request a rolled bar $\frac{13}{16}$ in. diameter was prepared at the Broughton Copper Works from the same "cathode" copper as that used in the research. Analysis showed that it contained 99.96 per cent. of copper. In order to thoroughly soften it, the bar was slowly cooled from 800 degrees C. (1,472 degrees Fahr.). The tensile-stress test gave the following results:—

Yield-point. Tons per sq. in.	Ultimate stress. Tons per sq. in.	Elongation on 2 inches. Per cent.	Reduction of area. Per cent.
3.0	14.17	56.0	67.84

These figures may be compared with those obtained from alloy No. 1, in all respects similar as regards physical treatment and composition, except that it contains 0.10 per cent. of aluminium and 99.86 per cent. of copper:—

4.4	14.18	62.0	92.52

The tenacities are the same, but the ductility of No. 1 is very much superior. The effect of this small percentage of aluminium is equally well marked in torsion and electrical-conductivity tests.

(*g*) A study of Tables 33 to 44 shows that, up to 9.4 per cent. of aluminium, the ultimate stress of the rolled bar $\frac{13}{16}$ in. diameter (untreated) is always higher than that of the chill casting (untreated). (As previously pointed out, the

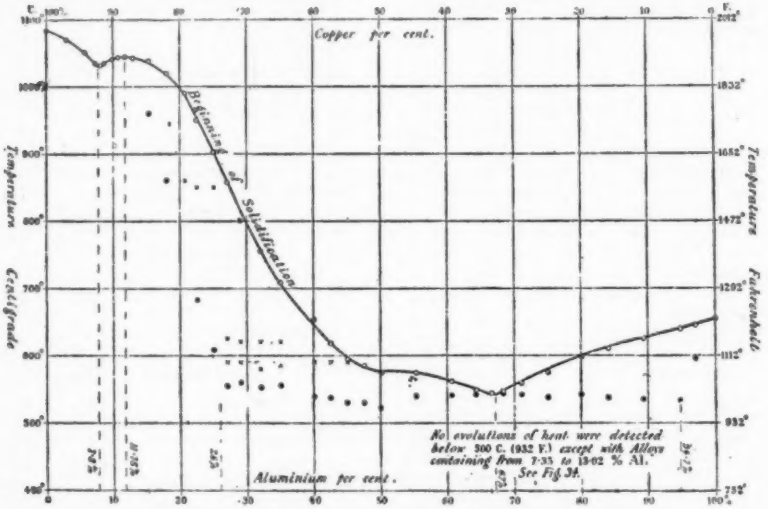

Copper per cent.
Brightness of Solidification
Temperature Centigrade
Temperature Fahrenheit
No evolutions of heat were detected below 300 C. (932 F.) except with Alloys containing from 7·35 to 13·02 % Al.
See Fig. 34.
Aluminium per cent.

FIG. 3.—FREEZING CURVE OF COPPER ALUMINIUM ALLOYS.

tenacity of the chill is usually superior to that of the sand casting.) The amount varies between 3 and 10 tons per square inch. In Table 45, however (Alloy No. 13), it will be noticed that the chill casting has a tenacity of 37 tons per square inch, and an extension of 30.5 per cent., as against the 38 tons and 29 per cent. extension of the rolled bar. These properties are practically identical. Further, the tenacity of the chill is 2 tons higher than that of the rolled bar $1\frac{1}{4}$ in. diameter. This must be regarded as an astonishing result. The authors have searched for a parallel among other known alloys, but without success. So far as they are aware, it is a unique exception

to the view generally held that rolled is superior to cast material.

No. 14 presents a very similar case. The chill casting is 1.73 tons better than the 1¼-in. diameter bar, but it is nearly 2 tons worse than the rolled bar $\frac{13}{16}$ in. diameter, and its extension is 5 per cent. lower.

That the long-known aluminium bronze or aluminium gold, containing 10 per cent. of aluminium, should be as strong and as ductile when cast in chill (1 in. diameter), as when rolled from a 3-in. diameter ingot down to $\frac{13}{16}$ in., appeared to the authors to be of such importance, both practically and theoretically, that they have confirmed it by making and testing other casts and bars, and by having the results checked by an independent worker.

Structures.

The structures revealed by the microscope throw considerable light on the classification of the alloys into two chief classes under the mechanical tests. Up to 7.35 per cent. of aluminium the alloys consist of ductile crystals of a solid solution. Heat treatment affects the size of the crystals to some extent, but does not cause profound structural changes as in the case of alloys containing from 9 to 11 per cent. of aluminium. Its influence on mechanical properties is not very far-reaching. On the other hand, the crystals are very much broken up by rolling and are interlocked into a tougher combination than the cast material.

The sudden stiffening of the alloys beyond 8 per cent. of aluminium coincides with the appearance of a dark structural constituent, which has been shown by microscopic examination to be acicular. Instances of the association of brittleness with an acicular structure are well known. At 11.73 per cent., where the structure is wholly acicular, the alloy has only slight ductility.

Heat Treatment Tests.

Alloy No. 13 was the most thoroughly tested of the series on account of its sensitiveness to heat treatment. The results are shown graphically in Fig. 2. They show that between 300 degrees and 400 degrees C. (572 degrees and 752 degrees Fahr.) this alloy undergoes a profound change. Comparing the results, it will be seen that after treatment at 300 degrees C. the properties are substantially the same as those of the bar as rolled, but that at 400 degrees C. there is a rise of nearly 100 per cent. in the elastic ratio, due to an increase in yield-point and decrease in ultimate stress. Most important of all, the ductility has dropped almost to nil. The fracture also is characteristically different. It is somewhat surprising that the microscope reveals no evidences of structural change in the alloy. The etched surface appears identical with that of the untreated bar. From 500 degrees to 700 degrees C. (932 degrees to 1,292 degrees Fahr.) there is a slight return of ductility and the elastic ratio falls, both yield-point and ultimate stress decreasing. At 800 degrees and 900 degrees C. (1,472 degrees and 1,652 degrees Fahr.) there is a further loss of strength, and the fracture becomes coarsely crystalline.

These results show that the properties of the 10 per cent. aluminium bronze are most injuriously affected by heat treatment at even moderately low, as well as high, temperatures; 400 degrees C. (752 degrees Fahr.) appears to be particularly fatal. This fact, unfortunately, limits the usefulness of this otherwise valuable alloy and prevents its application to any moderate or high-temperature work. Time has not permitted the authors to carry out strength tests on this alloy at varying temperatures.

Ball Hardness Tests.

The results are of the same kind under the two loads, viz., 1,034 and 3,000 kilos. The values in the table given in the report represent "standard" numbers, and only these will be considered. The hardness number 66 was obtained for No. 1, the base of the series. The introduction of aluminium at once hardens the material, but there is no very notable increase in the number up to 7.35 per cent. At 10 per cent. there is a marked rise, and from here up to 15.38 per cent. the increase is rapid. At the last-named percentage the figure 539 was obtained. This is more than eight times that obtained for No. 1, and must be considered a very high figure for an alloy that is not a steel of some kind. The figure for the hardest steel known is about 800, and although this is considerably higher than 539, yet the latter is just about the hardness number of a 0.45 per cent. carbon steel quenched in water at 20 degrees C. (68 degrees Fahr.), and is only slightly lower than that of a 0.66 per cent. carbon steel similarly treated. Accordingly

alloy No. 17 is fully entitled to rank with these hardened steels in this respect.

Alloys containing aluminium up to 7½ per cent. behave extremely well under the torsion test, but beyond this percentage there is a rapid deterioration of properties.

Under Stanton's alternating stress test the 10 per cent. aluminium bronze (alloy No. 13) shows itself a most useful material. Its maximum limit of resistance for one million reversals of direct stress at a rate of 800 per minute and with a ratio of tension to compression of 1.4 is about 28.3 tons per square inch. Comparing this figure with those obtained by Messrs. Stanton and Bairstow for ten varieties of iron and steel, the alloy takes the third place, equal to piston-rod steel, containing 0.446 per cent. of carbon. (The highest figure, 31.5 tons, was obtained with Swedish Bessemer steel (0.645 per cent. carbon).)

But the particular merit of this alloy (and also the 5 and 7½ per cent. bronzes) is the close approximation of the maximum stress under which it will bear an unlimited number of reversals to the stress at the elastic limit as determined in a tensile test. In this respect it is markedly superior to the iron and steel specimens hitherto investigated.

Summary of Kinetic Stress Tests.

These tests have yielded one result of particular interest. They have shown that the primitive yield-points of these alloys are very much nearer the proper figure than those of steels, or, in other words, that the alloys show much less tendency to assume an artificial yield-point in their manufacture. Alloys Nos. 9 and 13 are nearly theoretically perfect in this respect.

The alloys containing from 0 to 10 per cent. of aluminium behaved very satisfactorily in these tests, but the most valuable range is from 5 to 10 per cent.

Freezing Curves.

The complete results are shown graphically in Fig. 3. The circles, dots, and crosses represent observed evolutions of heat. The line drawn through the circles represents the "liquidus" curve; that is, the temperatures at which the molten alloys begin to deposit solid crystals on cooling. The curve agrees well with that obtained by Mons. L. Guillet except in one particular, namely, the authors have not found that the curve rises from 44.5 to 50 per cent. of aluminium. Near this percentage it is nearly a horizontal straight line.

The alloys containing from 0 to 13 per cent. of aluminium, whose properties have been investigated in such detail, appear to solidify at one temperature. From 8 to 13 per cent. evolutions of heat take place on cooling at temperatures for the most part between 600 degrees and 500 degrees C. (1,112 degrees and 932 degrees Fahr.). These have been investigated by differential cooling, and are discussed in the succeeding section. Fig. 3 only contains observations of direct cooling. The rise in the liquidus curve from 8 to about 12 per cent. of aluminium coincides with the appearance and growth to a maximum of the dark needles in the alloys after they have cooled to the ordinary temperature. But this must be carefully distinguished from the fact that the alloys solidify to an apparently homogeneous mass, from which the dark and yellow structural constituents are ultimately formed.

A Comparison of the Properties of Alloy No. 13 with those of Swedish Bessemer Steel of about 0.35 per cent. of Carbon.

The research has brought out a fact of very remarkable interest, namely, that the qualities, both mechanical and physical, of alloy No. 13 resemble those of a Swedish Bessemer steel of about 0.35 per cent. of carbon to a truly astonishing degree. When it is remembered that the former is an alloy of copper and aluminium, the latter an alloy principally of iron, carbon, and manganese, the parallelism of qualities appears especially interesting. It is, however, a matter of surprise that the resemblance between two well-known alloys—for No. 13 is the so-called aluminium bronze or aluminium gold—has not hitherto, so far as the authors are aware, been adequately described.

Properties of the Rich Aluminium Alloys (Specific Gravities).

As was found for the rich copper alloys, so here the specific gravities of the chill castings and rolled bars are identical. The identity also extends to the drawn bars so far as they have been examined.

With the introduction and addition of copper up to 8 per cent. the specific gravity rises regularly, and a smooth curve results. The specific gravities of the sand castings are lower and vary less

uniformly than those of the chill castings and rolled bars.

These alloys appear to be unaffected by such heat treatment as quick or slow cooling.

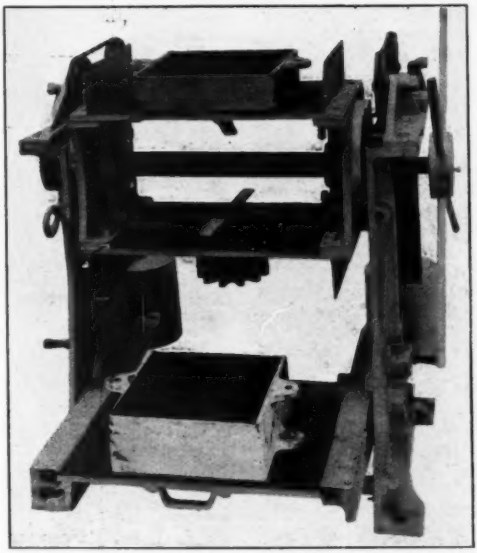
Small chill castings possess superior mechanical qualities to sand castings.

In order to get the full value of the inherent properties of the alloys, a considerable amount of mechanical work, *e.g.*, rolling or drawing, with or without annealing, should be performed on them. From 0 to 8 per cent. of copper all the alloys roll well, and from 0 to about 4 per cent. of copper they draw sound. As an illustration of the beneficial effect of mechanical work, alloy No. 37 is selected. The improvements effected in yield-point and reduction of area are particularly noticeable and important. An alloy whose specific gravity is only 2.79, whose yield-point is 18.5 tons, and whose reduction of area is 20.84, may have an industrial future in cases where a combination of lightness and strength is desired.

The tests of the sand and chill castings, of the rolled and drawn bars, agree in showing that nothing is to be gained by adding more than 4 per cent of copper to aluminium.

CLIFT'S UNIVERSAL MOULDING MACHINE.

A MOULDING machine has recently been designed and constructed by Thomas Middleton & Company, Limited, of Loman Street, Southwark, S.E. For repetition work it is particularly useful. The makers claim for this machine: (1) that there is an accurate lift which prevents any breaking of the mould and consequent time lost in mending up; (2) that the boxes are perfectly registered when placed together; (3) that no rapping is required; (4) that the operator works in an upright position.



CLIFT'S MOULDING MACHINE.

The machine consists of a frame which carries a revolving table that has two faces parallel to each other. Beneath this table there is another, also parallel, which slides in and out horizontally, the amount of movement being determined by stops. The revolving table is also provided with stops, so that it is always brought into an exact horizontal position after it has been turned. The arrangement of the tables is clearly shown in the engraving. It will be noticed that the revolving table can be raised or lowered by means of the rack and pinion gear controlled by the capstan handle.

Large weights are used to counterbalance the moving weight. It is necessary for the mould boxes to occupy a determined position on the table, and so they have small lugs cast on them, pierced with holes which correspond to the projecting pegs on the tables.

When making a mould one of the revolving table faces is brought into a horizontal position at the top. There are several small holes in the face of the table, provided so that the pattern can be secured to the face of the table by means of a screw. The part of the pattern, the mould of which is to be impressed in the lower half of the casting-box, is secured in this manner, and the lower half of the box then placed in position on the pegs. The levers shown in the centre of the lower table actuate clamps which hold the box firmly. The box having been clamped, sand is rammed in carefully, the back being strickled off and vented if necessary. The table is then turned round, lowered on to the pegs on the lowest table, the clamp released, and the box left free. The screw holding the pattern is taken out, and the table raised. The bottom table is then drawn forward, and the top half of the box placed on the lower half, and the remainder of the pattern put in position. Parting sand is sprinkled on the top of the lower mould, after which ordinary sand is rammed in. The table is then pushed back against the stop. The revolving table is lowered until the pins have engaged with the lugs of the top box. The box is then clamped to the table as before, and the table raised and turned round. Without being again turned, it is now lowered until the face of the lower side of the table touches the bottom box. The pattern in the box in then secured as before, that is by means of a screw, and withdrawn by raising the table. The other part of the pattern is then withdrawn from the top half of the box. The table is again turned round and lowered, and brought in its position relatively with the lower box, and the two are secured by bolts and nuts. The clamps are then released from the top half of the box, the table drawn forward, and the boxes lifted off the pegs ready for casting. If there are any cores they are now placed in position.

No special sand is required for moulding, and it will be seen from the description that the machine is capable of dealing with a large number of patterns that can be made in halves, or in such a manner that there are two flat faces. We have seen this machine at work, and were satisfied that the makers justified their claims. The work done by it was good, and required practically no finishing. The castings that we saw obtained from these moulds were quite clean, free from blow-holes, and in only a very few cases could the junction of the two boxes be seen.

Three sizes of machines are made. No. 0 size takes boxes 9 in. by 9 in., and 12 in. by 12 in. by 4½ in. deep. No. 2 takes boxes 12 in. and 15 in. square by 6 in deep, and the largest size takes boxes 15 in. and 18 in. square by 7½ in. deep. The size of castings made is only limited by the size of the box.

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TRADE TALK.

Messrs. Drysdale & Company, Glasgow, are about to erect new works at Yoker.

Harland & Wolff, Limited, Belfast, have opened offices at Cockspur Street, London.

Wm. Asquith, Limited, engineers, Halifax, are establishing new works in the town.

Messrs. Walters & Company, engineers, have removed to Ocean Chambers, Birmingham.

Messrs. Flannery, Baggallay & Johnson have opened an office at Boompjas 82, Rotterdam.

Messrs. Berry, Skinner & Company have considerably extended their Birmingham works.

The Union Foundry Company has decided to establish new works at Walkden Moor, Little Hulton.

Messrs. Vivian Younger & Bond have removed to Baltic House, 27, Leadenhall Street, London, E.C.

Messrs. R. L. Shaw and G. E. Shaw, ironmasters, Huyton Quarry, Lancashire, have dissolved partnership.

Messrs. B. Harlow & Son lately secured a contract to supply castings to the Macclesfield Corporation.

The Bell-Cecil Range Company are starting the manufacture of iron castings and firegrates at Northampton.

Messrs. Crossley & Davenport, Birmingham, have established an office at 7, Cartaret Street, Queen Anne's Gate, S.W.

THE business of Charles Wickstead & Company, engineers, Kettering, has been formed into a private limited liability concern.

CONSIDERABLE extensions have lately been completed at the works of the Campbell Gas Engine Company, Limited, Halifax.

MESSRS. J. E. BILTON and E. C. HARRIS, Heckmondwike, Yorkshire, trading under the style of the General Engineering Company, have dissolved partnership.

IN connection with the affairs of Mr. E. G. Whitehouse, trading as Whitehouse Brothers, Hurst Lane, Tipton, ironfounder, a composition of 8s. in the £ has been paid.

HERR CARL KAEMMERLING, tool maker, of Elberfield, Germany, has appointed Mr. J. H. Taylor, of 35, Barbara Street, Barnsbury, London, N., as his sole agent in Great Britain.

THE casting patterns of the Amalgamated Brass and Engineering Company, Limited, Birmingham, have been acquired by Messrs. Allen & Freeman, Small Heath, Birmingham.

MESSRS. C. TENNANT and J. W. GILLESPIE have acquired the business of Mr. J. Holmes, Grangemouth, and will carry it on under the style of the Dundee Engineering Company.

A DISSOLUTION of partnership is notified in connection with Messrs. W. B. Dell and J. F. Stewart, general engineers, etc., Mark Lane, E.C., and Reliance Iron Works, Croydon, Surrey.

JOHNSON & PHILLIPS, LIMITED, have appointed Messrs. Welding & Company, 64, Stanley Street, Liverpool, and Manchester, to represent them in the counties of Lancashire and Cheshire.

MR. A. ASH, of Ash & Lacy, Limited, Birmingham, and Great Bridge, Tipton, Staffs., has acquired the Huyton Quarry Sheet Iron Works, near Liverpool, lately carried on by Messrs. C. & L. Shaw.

MESSRS. W. A. SPARROW & COMPANY, 14, St. Mary Axe, London, E.C., who have admitted Mr. A. P. Bidmead into partnership, have opened a branch office at 37, Chapel Chambers North, Liverpool.

MESSRS. R. LAIDLAW & SON, of the Alliance Foundry, Glasgow, are supplying the Cupar District Committee of the Fife County Council with 3 in. and 4 in. diameter cast-iron pipes, to the value of £2,160.

THE UNBREAKABLE PULLEY AND MILL GEARING COMPANY, LIMITED, West Gorton, Manchester, have appointed Mr. A. J. Crawford, Carlisle, their sole agent in Cumberland, Westmorland, and Furness in Lancashire.

MESSRS. JAY, BROLL & COMPANY, 31, Old Queen Street, Westminster, S.W., have been appointed London managers to Messrs. Cordingley & Company, Trowbridge, Wilts, and Messrs. Isaac Brierley & Company, of Royston, Lancashire, and also sole agents in Great Britain of Mr. Max Hubner, of Breslau.

THE Council of the Birmingham University has established an advisory board of business men to co-operate with the professors in the Faculty of Commerce, on which the following gentlemen have agreed to serve:—Mr. N. Chamberlain, director of Elliott's Metal Company, Limited; Mr. G. H. Claughton, agent of the Earl of Dudley, and a director of the company; Mr. F. Dudley Docker, chairman of the Metropolitan Railway Carriage and Wagon Company, Limited; Mr. A. H. Gibson, director of W. & T. Avery, Limited, and J. & E. Wright, Limited; Mr. E. Hickman, joint managing director of Alfred Hickman, Limited; Mr. W. E. Hipkins, managing director of W. & T. Avery, Limited, and a director of J. & E. Wright, Limited; Mr. J. S. Taylor, director of the Lanchester Motor Company, Limited; and Mr. T. Sydney Walker, managing director of Thomas Walker & Son, Limited.

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DEATHS.

MR. JOSEPH WALMSLEY, malleable-iron founder, of Halifax.

MR. F. R. WHITFIELD, secretary of the Taymouth Engineering Company, of Carnoustie.

MR. J. DERBYSHIRE, engineer and ironfounder, Britannia Works, Longton, at the age of 81 years.

MR. W. E. THORRINGTON, secretary to the Britannia Engineering Company, Limited, Colchester, aged 53 years.

MR. F. R. BOOTH, managing director of the Kelham Rolling Mills Company, Limited, Sheffield, at 56 years of age.

MR. P. A. FIELD SADLER-BLAIR, head of Messrs. Blair & Company, engineers, Stockton-on-Tees, at 40 years of age.

Mr. John Whittaker, founder of the firm of Whittaker Bros., Pioneer Iron Works, Accrington, at the age of 80 years.

Mr. J. H. Bury, who had for many years carried on business at the Vulcan Works, Oswaldtwistle, near Accrington.

Mr. James Clayton, the inventor of the Clayton air compressor and many other compressed air machines. The deceased gentleman was a native of Homer, in Shropshire.

Mr. William Henry Davies, general manager of the Shelton Iron, Steel and Coal Company, Limited, who was formerly the manager of the Monmouthshire Steel and Tinplate Company's works at Pontymister.

Mr. James Melling, of 52, Earl Marshal Road, Pitsmoor, Sheffield, at the age of 64. The deceased gentleman had been in the employ of Messrs. Cammell Laird & Company for upwards of forty years, and was at one time manager of the Yorkshire Steel and Iron Works, Penistone.

—o—

NEW COMPANIES.

County Engineering Company, Limited.—Capital £2,000.

Werner-Stuart Steam Generator Syndicate, Limited.—Capital £10,000.

Siberian Metals, Limited.—Capital £1,000. Registered office: 7, East India Avenue, E.C.

Grafton's, Limited.—Capital £5,000, in £1 shares, to carry on the business of iron founders.

John Butler & Company, Limited.—Capital £100,000, to acquire the Stanningley Iron Works, Leeds, of John Butler & Company's Trustees.

The Aluminium Castings Company, Limited.—Capital £20,000, to acquire the existing business. Registered office: 11, Ingleston Street, Greenock.

John Urmson, Limited.—Capital £6,000, to carry on the business of founders, etc. Registered office: Wellington Road, Ashton-under-Lyne.

Ernest H. Hill, Limited.—Capital £12,000, to take over the business of brassfounders, etc., carried on at Broomhall Street, Sheffield, as Ernest H. Hill.

Botts, Limited.—Capital £2,000, to carry on the business of bedstead manufacturers, brassfounders, etc. Registered office: Falcon Works, Glover Street, Birmingham.

Watson, Laidlaw & Company, Limited.—Capital £100,000, to acquire the business of engineers, of Watson, Laidlaw & Company. Registered office: 98, Dundas Street, Glasgow.

Williams & Pascoe, Limited.—Capital £1,000, to acquire the business carried on at 106, Pembroke Place, Liverpool, as Williams & Pascoe, and to carry on the business of engineers.

C. H. Mason, Wilson & Company, Limited. Capital £1,000, to acquire the engineering business of C. H. Mason and F. T. Wilson, Gateshead. Registered office: 18, West Street, Gateshead-on-Tyne.

John Phythian, Limited. Capital £16,000, to acquire the business of the Phythian Engineering Company, Limited, of Congleton, amalgamated with A. E. Berry & Company, Limited, Sowerby Bridge.

Ward Brothers (Blackburn), Limited. Capital £9,000, to acquire the iron-founding business carried on at Blackburn, as Ward Brothers. Registered offices: Ingham Street Iron Works, Ingham Street, Blackburn.

Lee & Wilkes, Limited.—Capital £20,000, to acquire the business of a coppersmith and brassfounder, carried on by C. Lee, at 19, Freeman Street, Birmingham, and the similar business carried on under the style of E. V. Wilkes, at Priory Copper Works, Birmingham.

—o—

PERSONAL.

Mr. W. B. Rudge, ironfounder, of Stafford, has been made a J.P. for the borough.

The late Mr. H. Swingler, director of the Victoria Iron Works, left estate valued at £351,023.

Mr. H. Philipson has been elected chairman of the North-Eastern Marine Engineering Company.

Mr. D. Jackson has been admitted into partnership by Messrs. Wm. Denny & Brothers, Dumbarton.

The estate left by the late Mr. J. C. Loeffler, who was connected with Siemens, Bros. & Company, Limited, has been valued at £1,505,004 gross.

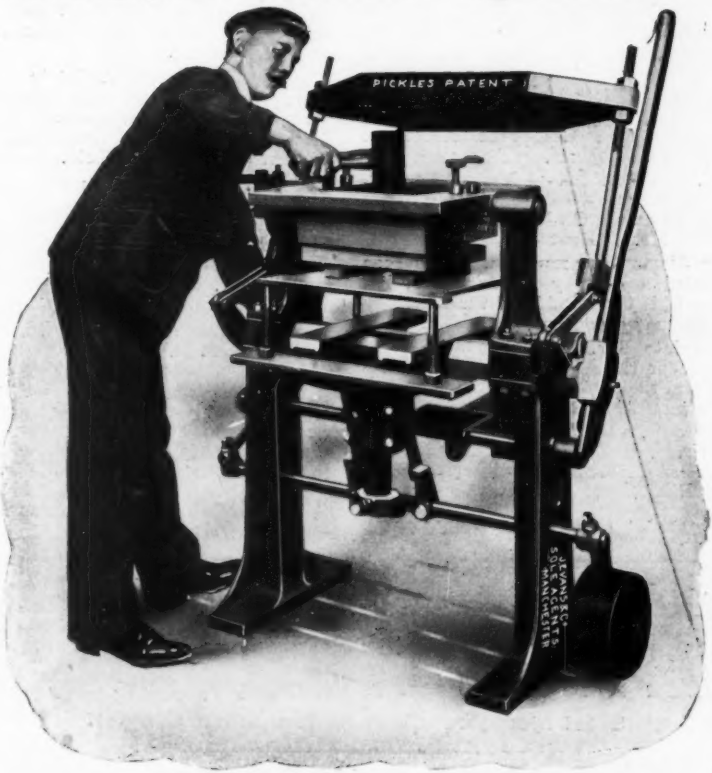
Mr. G. B. Hunter, of Swan, Hunter & Wigham Richardson, Limited, has been

NEW MOULDING MACHINE.

PICKLES' PATENT.

ASK FOR LIST AND FULL PARTICULARS.

COMPLETE FOUNDRY EQUIPMENT.



JAMES EVANS & CO.,

Britannia Works, MANCHESTER.

TELEGRAMS: "LADLES, MANCHESTER." "BLACKINGS. GLASGOW." TELEPHONE: 2297, MANCHESTER. 3185, BRIDGETON, GLASGOW.

elected a vice-president of the Decimal Association.

Lord Pirrie, chairman of Harland & Wolff, Limited, has been elected a director of the London City and Midland Bank, Limited.

Mr. E. Griffith and Mr. W. Brock, Junr., have been assumed as partners by Messrs. Denny & Company, engineers, Dumbarton.

Mr. J. Lloyd, secretary to Sir James Laing & Sons, Limited, has decided to retire, and will be succeeded by Mr. W. Richardson.

Professor H. M. Howe has received the Order of St. Sanilas from the Czar in recognition of his work in metallurgical research.

Mr. L. D. Whitehead, one of the proprietors of the Deighton Iron Works, Tredegar, has just returned from a tour in the United States.

The estate left by the late Mr. F. Bradley, of Messrs. F. Bradley & Son, Clansmore Iron Works, is valued at £35,105 4s. 6d. gross.

Mr. J. Gilchrist, of Messrs. Barclay, Curle & Company, shipbuilders, has been appointed on the Clyde Trust, in place of the late Mr. J. Rowan.

Sir James Woodhouse, who has been appointed a Railway Commissioner, has resigned his directorship of the Rhymney Iron Company, Limited.

The late Mr. Roland Philipson, a director of the Wallsend Slipway Company and the Consett Iron Company, left estate valued at £510,723.

The gross value of the estate of the late Mr. E. Ludlow, a director of Alldays & Onions' Pneumatic Engineering Company, Limited, is £25,080.

Mr. M. S. Gibb, son of Sir George Gibb, has joined the staff of Messrs. Gray & Company, Central Marine Engine Works, West Hartlepool.

The late Mr. W. H. Westwood, of Messrs. Westwood & Wright, engineers, Dudley and Brierley Hill, left estate of the gross value of £98,888.

Mr. E. G. Appleby, chairman of the late firm of Jessop & Appleby Brothers, Limited, is the managing director of the new concern known as Appleby's, Limited.

The late Mr. E. Gamble, of Messrs. Moss & Gamble Brothers, Sheffield, steel, file, saw, and edge tool manufacturers, left estate of the gross value of £16,153 4s. 6d.

Mr. J. W. P. Scott has left the Walker Shipyard of Sir W. G. Armstrong, Whitworth & Company, Limited, to take up an important post under the Carron Company at Stirling.

Mr. C. G. Norris, lately general manager for Masons Gas Power Company, Limited, is now associated in business with Mr. G. P. Wincott, engineer, 16, Saville Street, Sheffield.

Mr. J. Beck, foreman moulder in the foundry department of the works of Richardson, Westgarth & Company, Limited, has been the recipient of a presentation on the occasion of his leaving for Glasgow.

Amongst new magistrates for the City of Birmingham are the following gentlemen:—Mr. T. E. Mitton, steam, engine, and boiler fitting maker, Moseley; Mr. D. T. Young, a partner in the firm of Messrs. Youngs, engineers, Ryland Street; Mr. W. J. Davis, general secretary of the National Society of Amalgamated Brassworkers and Metalworkers; and Mr. J. S. Nettlefold, a director of Kynochs, Limited, and chairman of Thomas Smith's Stamping Works, Limited.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

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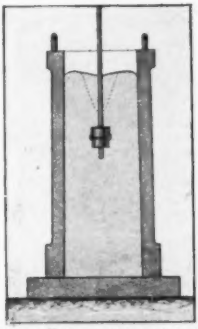
Telegrams: "LOWOOD, DEEPCAR."

Reducing Piping in Steel Ingots.

STEEL BLOCK SHOWING PIPING.



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ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	1905-6.	1904-5.
Iron—Scotch pig warrants ... ton	*63/0	—
—Middlesbro' warrants ... ... ton	56/5	52/9
—W.C. M/nos Bessemer ... ... ton	81/6	70/6
—Stock, Scotch, Jan. 31 ...tons	5,200	14,700
Copper—Chili bars, GMB ... ... ton	£106 7/6	£78 12/6
—Stock, Europe & afloat... ... tons	—	—
Tin—English ingots ton	£192 15/0	£168 15/0
—Straits ... ton	£189 15/0	£166 5/0
—Stock, Ldn. Hlnd and aflt ... tons	14,165	15,115
Lead—English pig ton	£20 0/0	£16 18/9
Spelter—Ord. Silesian ... ... ton	£26 15/0	£27 5/0
Quicksilver-(75lb.) bottle	£7 0/0	£7 7/6
Antimony—Regulus ... ... ton	£105-£110	£65 0/0

*Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	7 0 0	to	7 5 0
Pipes, 1½ to 2½ in.	5 12 6	to	5 15 0
,, 3 to 4 in....	5 5 0	to	5 12 6
,, 5 to 8 in.	5 2 6	to	5 5 0
,, 10 to 16 in....	5 2 6	to	5 5 0
,, 18 to 24 in....	5 2 6	to	5 5 0
Chairs	4 2 6	to	4 5 0
Floor plates (open sand)	3 10 0	to	3 12 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: — Heavy wrought (mixed), £3 5s.; light wrought, £1 15s.; heavy cast, £1 12s. 6d.; all per ton f.o.b., London. Copper (clean), £97; brass (clean), £68 10s.; lead (usual draft), £18 10s.; tea lead, £16 15s.; zinc, £21 15s.; all per ton delivered merchant's yard.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

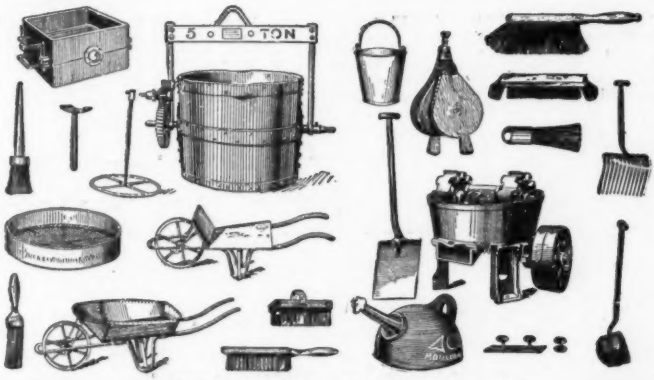
Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE, Near Sheffield.

Manufacturers of all

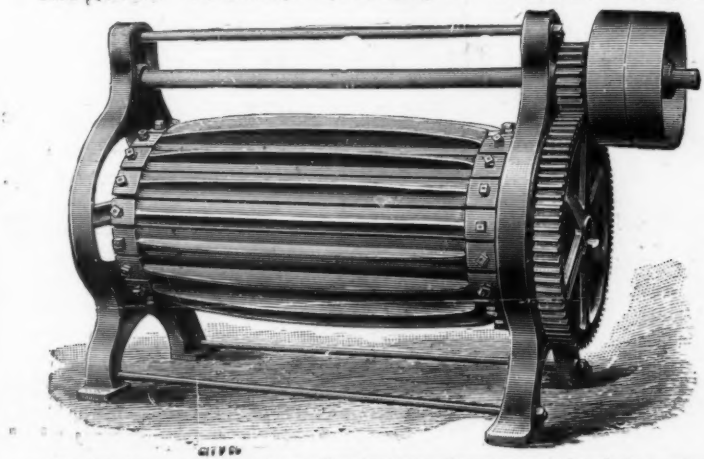
FOUNDRY EQUIPMENTS,

Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

"Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

In USE throughout the FOUNDRIES of the WORLD.

METALLIC CEMENTS

For ALL Purposes.

THOROUGHLY EFFICIENT AND RELIABLE.

PATENT EAGLE IRON CEMENT.
FUSIBLE CEMENT FOR CASTINGS.
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METAL CEMENT FOR FOUNDATION BOLTS.
IMPROVED DIAMOND CEMENT.
STEEL CEMENT
BRASS CEMENT
BRONZE CEMENT

Specially prepared for use in Steel, Brass and Bronze Castings.

The whole of the above Cements are specially prepared to fulfil the requirements of Iron and Steel Founders, Brass, Bronze, etc., Casters, and have attained their present large sale solely in virtue of their superiority.

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No. 1a size, "Allday's," 6 in. outlet, £18.
No. 1 „ „ 7 in. „ £19.
No. 2 „ "Thwaites," 8 in. „ £20.
with Engines and Boilers to drive.
Address J. LIGHT, Wolverhampton.

TO BRASS FOUNDERS & ENGINEERS.—Complete Analysis of any Alloy, 25s.—L. PARRY, A.R.S.M., Union Bank Yard, Huddersfield. Speciality—Brasses, Bronzes, Anti-Friction Metals. 12 years' experience.

ONE 1-Ton ELECTRIC TRAVELLING CRANE, by Jessop, all motions, 4 ft. 8½ gauge, with 10-h.p. Motor, wall-box, and cable; splendid condition.—WILLIAM JONES, 154, Upper Thames Street, E.C.

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ROOTS' BLOWER, No. 5, steam-driven, capacity 6,400 cubic feet of air per minute; has been very little used, and is in perfect condition; cheap to clear.—JOSEPH PUGSLEY, St. George, Bristol.

HEATER and FAN, belt-driven, by Bourne Engineering Co., only used a few weeks; cost £200; price £120.—Write G. WATSON, 7, Southampton Row, London.

CUPOLA LININGS.

HIGH-CLASS QUALITY

FIRE BRICKS

Made from specially selected clays.

BEST CRUCIBLE CLAYS.

Blast Furnace, Hot Air Stove, Boiler Seating, Flue Cover, and other Best Fire Bricks.

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FINEST MATERIAL FOR LINING CUPOLAS AND FURNACES AND SETTING FIRE-CLAY BRICKS.

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No linseed oil or flour required.

NEW PORTABLE MOULD DRIERS

Moulds dried on the spot in an hour to one hour and a half.

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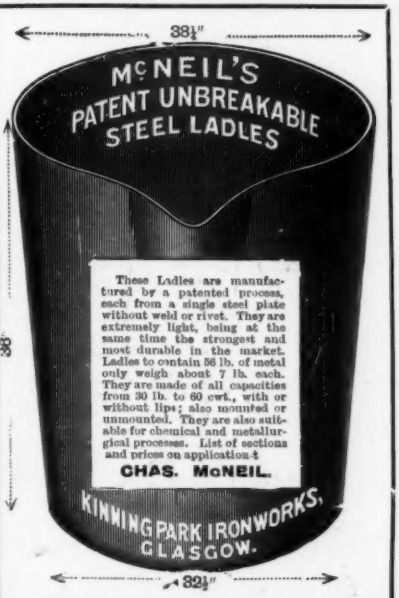
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PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application.
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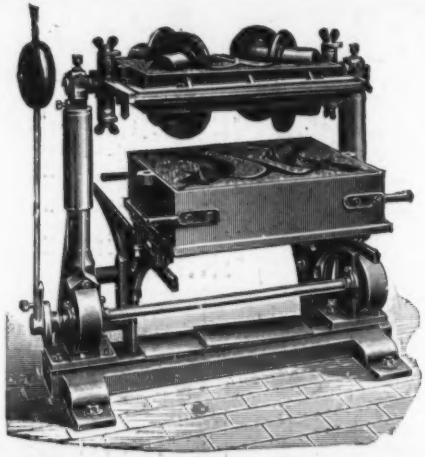
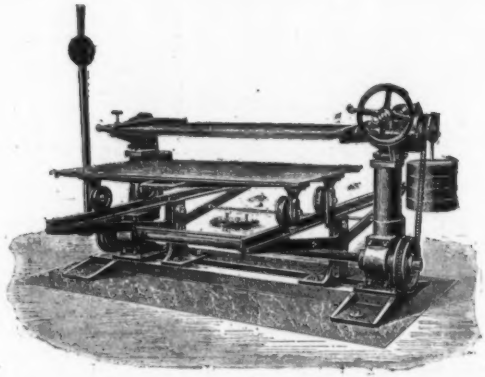
GLASGOW.
32½"

Can also be made in Aluminium.





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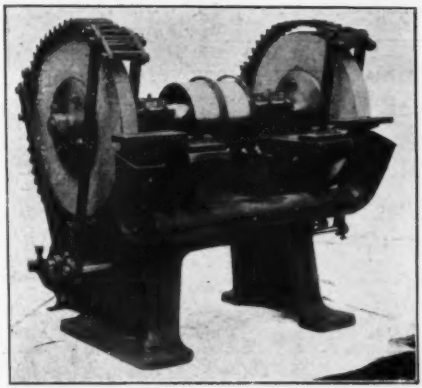

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For Foundry Use

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ALL CLASSES OF

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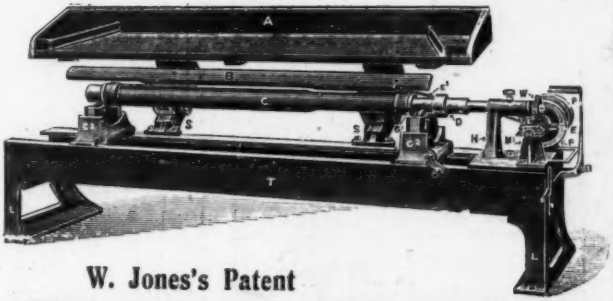
For Pipe Cores, 18 ft. long and 2 in. to 20 in. diameter.



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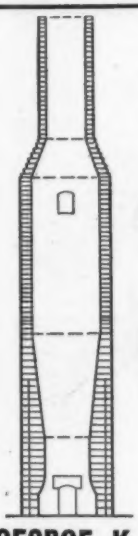

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38¼"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application t
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32¼"

Can also be made in Aluminium.

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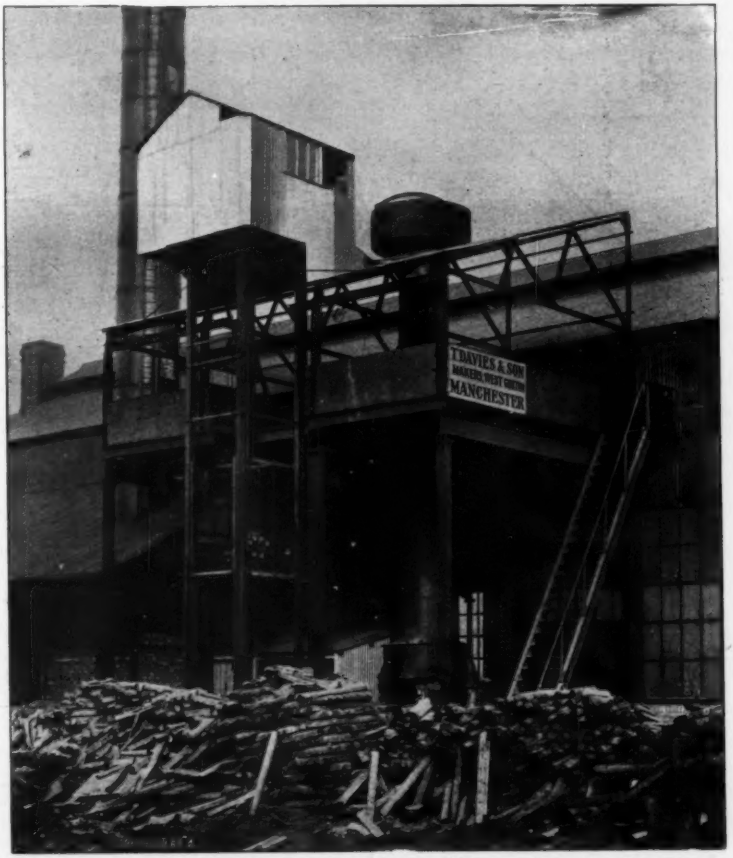

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Speciality:— FOUNDRY CUPOLAS OF ALL TYPES,

UPWARDS OF 500 MADE AND SOLD,

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COMPLETE MELTING PLANTS SUPPLIED.

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FIRST CLASS PATTERN PLATES

are now being made by moulders in foundries, with

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No method of making repetition work in foundries **is complete without** a simple ready system of making pattern plates as required for either hand or machine moulding.

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COAL DUST and other Foundry Requisites.

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BRUSHES,	CHAPLETS & STUDS,	LADLES,
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MOOR & SONS, 1, Fennel St., MANCHESTER, (Dept. F.)

Established 1857. Telegrams "Acklam." Telephone, No. 3566.

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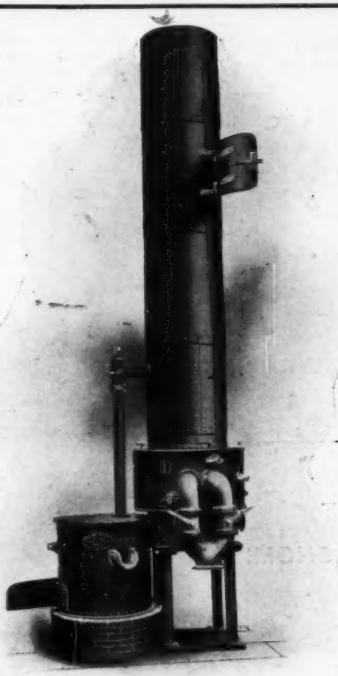

Cupolas,
with or without receivers or drop bottoms.

Roots' Blowers,
belt, steam-engine, or electro-motor driven.

Charging Platforms, Hoists, and Ladles.

ECONOMICAL RESULTS GUARANTEED.

We are also Manufacturers of Steam Hammers, Smiths' Hearths, Centrifugal Pumps and Fans, High-Speed Engines, and the "Bradford" Patent Boiler Feed Pump.

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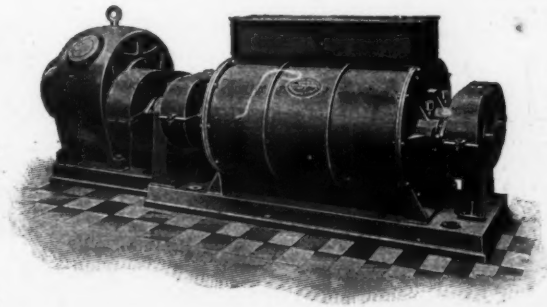

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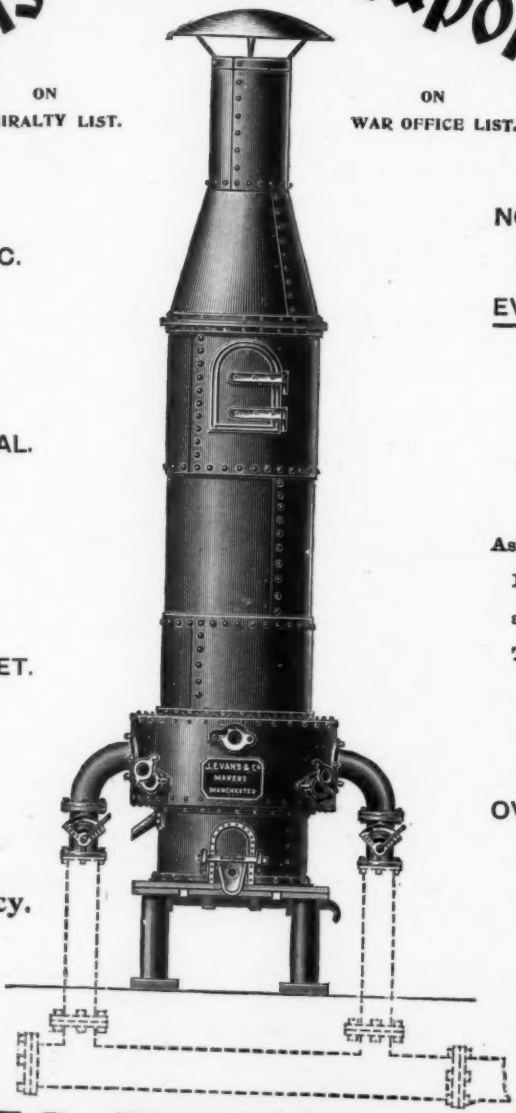

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